# CITY MILK SUPPLY

BY

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# PREFACE

The writer's experience as a health officer and as a teacher has led him to believe that there is need for a book telling something about milk, how it is produced and how it is transported and delivered to city milk consumers and of the methods of control adopted to insure its purity. The subject is a broad one and in its divisions touches several specialized fields which are the domain of experts so that necessarily the work of these men has been drawn on for material. The attempt has been made to give them due credit by lists of sources at the end of each chapter.

To the many dairymen and city milk dealers who have given cordial welcome to their farms and plants, to those who have supplied photographs and to the friends who have helped with advice in the preparation of the manuscript and in revision of the proof the author gives hearty thanks.

BOSTON, MASSACHUSETTS,
*January*, 1917.

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# CITY MILK SUPPLY

The milk business is not the farmer's business, nor the contractor's, nor yet the consumer's; it is the community's business, and unless the members of the community work together for good milk, they will never get it.

## CHAPTER I

### MILK

The city milk business of the United States is a development of the past 75 years. Prior to 1840 very little milk was shipped by rail; practically all of it was brought by wagons from farms in the surrounding country or was produced within city limits. At that time no city in the country had a population of half a million. Boston had about 100,000 inhabitants and New York City about 300,000. However, the largest cities were beginning to find the local sources of milk supply inadequate and were reaching out for country milk. By 1843 many farmers within 50 miles of Boston were shipping milk regularly by rail to the city and soon other cities got increasingly large amounts of milk in the same way. The business was a new one and naturally those who were engaged in it handled it in a crude way. Abuses crept in and became so flagrant that about 1860 the first attempts were made to regulate it, by discouraging the practices of skimming and watering. Apparently they were only partially successful. Meanwhile the milk business grew to importance without exciting more than a grumbling interest on the part of the public. However, it was about to enter a new era. In the period from 1885 to 1890 the regular collection of milk samples became common and the acceptance of the germ theory of disease led to the tracing of certain outbreaks of contagion to milk supplies. Soon, the medical profession, milk producers and the public recognized that the milk business must be reformed and put on a basis which would make the products above reproach. Regulation was undertaken with assurance and in a cavalier spirit but after many disappointments and bitter controversies it was gradually perceived that all concerned had much to learn before the problem of delivering immense quantities of good safe milk could be solved. Investigations of different phases of the question were made by physicians, bacteriologists, chemists, health officers, economists, engineers, railroad men, dairymen, lawyers and others. Manufacturers of dairy machinery so improved the devices used as to make the handling of milk cleaner and safer.

The result of all these forces is that in the last 25 years, there has emerged a new art, city milk supply, still far from perfect but which is advancing steadily.

**Importance of the Dairy Industry.**—Progress is being made along several different lines. Chemists are studying the composition of milk and the changes it undergoes in being made into various sorts of dairy products. Farmers are improving their herds and introducing more sanitary and economical methods of dairying. Railroads are solving the problems that arise in transporting milk and contractors, those that attend the gathering and distributing of enormous quantities of milk. Health officers are working out rational methods of milk control and the general public through various organizations of citizens, in whatever way it can, is helping to develop this important business.

It is estimated that in 1914 there were 20,737,000 dairy cows in the United States and that their total value was $1,118,487,000. The whole quantity of milk used raw on farms, raw in villages, as market milk in cities, in condenseries, for the manufacture of butter and cheese on the farm and in butter and cheese factories, is estimated at 9 billion gallons or 77.4 billion pounds per annum, to which should be added the milk used for feeding calves and other stock and that used in small quantities for other purposes. Of this milk, the market milk consumed in cities of over 2,500 inhabitants is 1 billion gallons or 8.6 billion pounds and, assuming the consumption per capita to be the same in villages of less than 2,500, the total use of milk therein amounts to 600,000 million gallons or 5.16 billion pounds.

**Consumption of Milk in the United States.**—The consumption of market milk in cities of the United States is often taken at 0.6 pt. per capita but this is a crude figure and is usually arrived at by dividing the total amount of milk distributed daily by the total population. The truth is, the wealthy and well-to-do get more milk than the poorer people so that the amount of milk used by the average citizen is considerably less than 0.6 pt. In order to get information concerning the use of milk in the home, Williams made a careful study of 15 sections of Rochester, N. Y. Each section differed from the others, in wealth, social position or nationality and all together they embraced over 5,000 or about one-tenth of the homes of the city. The result of the study is given in Table 1. It shows that the population of children under 5 years of age was greater among the poor than among the well-to-do. The consumption of milk by 21,600 people was 5,278 qt. of milk per day or at the rate of but little more than 0.24 pt. per capita. The poor not only used less milk and bought it in smaller quantities than the well-to-do but the use of store milk and of condensed milk was largely confined to the laboring classes.

Table 1.—Consumption of Milk in 15 Representative Sections of Rochester, N. Y. (Williams)

| Section | Class | Number of homes | Number of people | Children under 5 years | Amount milk used daily (quarts) | Families using daily— ½ qt. | 1 qt. | 1½ qt. | 2 qt. | 2½ qt. | 3 qt. | Families using— Certified milk | Condensed milk Exclusively | Condensed milk Partly | Store milk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Chiefly colored. . . | 231 | 1,128 | 67 | 245 | 51 | 122 | 10 | 24 | . . | 11 | 6 | 11 | 4 | 48 |
| 2 | American laboring | 523 | 2,308 | 159 | 532 | 131 | 242 | 21 | 67 | 50 | 18 | | 23 | 30 | 70 |
| 3 | American laboring | 462 | 2,067 | 143 | 475 | 135 | 204 | 28 | 53 | 1 | 16 | 2 | 21 | 37 | 103 |
| 4 | Well-to-do. . . . . . . | 283 | 1,176 | 67 | 398 | 35 | 132 | 27 | 61 | 1 | 26 | 14 | 1 | 10 | 4 |
| 5 | German-American laboring. . . . . . . . . | 527 | 2,647 | 234 | 626 | 117 | 231 | 41 | 80 | 36 | 39 | 2 | 8 | 6 | 28 |
| 6 | Well-to-do. . . . . . . | 115 | 518 | 19 | 169 | 12 | 57 | 9 | 24 | 1 | 11 | 5 | . . | . . | . . |
| 7 | Italian laboring. . . | 643 | 3,172 | 538 | 388 | 218 | 143 | 26 | 26 | 1 | 8 | 18 | 52 | 25 | 29 |
| 8 | Jewish laboring. . . | 477 | 2,316 | 310 | 623 | 65 | 170 | 63 | 103 | 4 | 26 | 11 | 16 | 32 | 28 |
| 9 | German laboring. . | 234 | 1,245 | 94 | 289 | 37 | 90 | 33 | 39 | 1 | 16 | . . | 10 | . . | 5 |
| 10 | American middle. . | 450 | 1,939 | 112 | 523 | 92 | 27 | 39 | 66 | . . | 21 | 8 | 4 | . . | 13 |
| 11 | Well-to-do. . . . . . . | 201 | 891 | 24 | 352 | 17 | 63 | 12 | 66 | . . | 32 | 18 | . . | . . | 1 |
| 12 | Well-to-do. . . . . . . | 99 | 495 | 20 | 190 | 5 | 24 | 8 | 24 | . . | 25 | 4 | . . | . . | 1 |
| 13 | Well-to-do. . . . . . . | 209 | 845 | 41 | 303 | 23 | 88 | 9 | 56 | . . | 20 | 29 | . . | . . | . . |
| 14 | American laboring | 191 | 851 | 57 | 165 | 72 | 59 | 12 | 19 | . . | 5 | . . | 18 | 11 | 10 |
| 15 | American laboring | 786 | . . . . . | 200 | 1,100 | 192 | 258 | 44 | 38 | 36 | . . | 2 | 39 | . . | 62 |

**Milk a Valuable Food.**—The milk industry has attained this importance because milk, skim-milk, butter and cheese are among the best and cheapest of foods. Most people are fond of them and digest them easily. Good fresh milk is all but essential to the welfare of young children, and to the nursling that for any reason is deprived of its mother's milk, cow's milk is practically indispensable. The reason that milk is such good food must be sought in its composition.

**Definition of Milk.**—Milk is the nutritive secretion of the mammary glands. In a general way all milks are similar for they are watery fluids containing fats, proteins, sugars, salts and gases. The fat is in suspension, the proteins are mostly in colloidal suspension but in part in true solution and the salts likewise are in solution and suspension, whereas the sugars and gases are in true solution. Each species of animal has its own peculiar milk; that of animals of the same species differs a little and the milk of a single animal is of slightly inconstant quality. Since in the United States the milk of the cow is the only one that is of commercial importance, it is the one with which this book deals.

**Breeding of the Cow.**—Under the best management a heifer is bred at 15 to 18 months of age, the period of sexual maturity being reached earlier by some breeds than others. After a period of gestation of 9 months she calves and comes into milk. At an estrum occurring about 3 months later, she is bred again, but continues to furnish milk for about 10 months when the nutrients that have been devoted to milk produc-

tion are needed for nourishment of the fetus so that the flow falls off and usually dries up. The udder then enters a resting stage, and the animal goes through a period of recuperation, or conditioning for 6 weeks or more, when she drops another calf and enters a second lactation period. If this rest is not given the cow she begins the new lactation period at a low level of production. Animals that remain farrow usually give milk for about 2 years, though some farrow cows continue in milk for a long time.

**Average Chemical Composition of Milk.**—The average chemical composition of milk is indicated in Table 2 which is made up from analyses from several sources, but in reality it is impossible to state the average composition exactly for the milk of every dairy district is determined by the dominant breed of cow; thus in a Holstein the average would differ from that of a Guernsey section and that again from one where the cows were mostly natives.

TABLE 2.—AVERAGE COMPOSITION OF COW'S MILK

| Number and source of analyses | Water | Fat | Milk sugar | Casein | Albumin | Ash | Other constituents |
|---|---|---|---|---|---|---|---|
| 280,000 analyses Aylesbury Dairy, England | 87.35 | 3.74 | 4.70 | 3.00 | 0.40 | 0.75 | 0.06 |
| 5,220 American analyses compiled by Van Slyke | 87.10 | 3.90 | 5.10 | 2.50 | 0.70 | 0.70 | ... |
| Average cheese-factory milk, New York State, May to November | 87.40 | 3.75 | 5.00 | 2.45 | 0.70 | 0.70 | ... |

The composition of milk varies. As a rule, the percentage of milk sugar and ash are most constant and that of the fat is most variable while the protein varies with the fat but to a smaller extent. According to Van Slyke the butterfat in the milk of an individual cow varies from less than 2 to over 10 per cent., the casein from 2 to 4 per cent., the albumin from 0.5 to 0.9 per cent., the casein and albumin together from 2.5 to 6 per cent., the lactose from 4 to 6 per cent., and the salts from 0.7 to 0.9 per cent. These variations in the constituents of milk may be regarded as usual: butterfat 3 to 6 per cent., solids-not-fat 8.5 to 9 per cent., proteins 3 to 5 per cent., milk sugar 4 to 6.5 per cent. and ash 0.7 to 0.8 per cent. The milk that reaches the consumer is usually the mixed product of several cows so that variations in the milk of the individual cows counterbalance one another with the result that considerable fluctuations rarely occur.

Commonly an analysis of milk includes only a determination of the specific gravity, the butterfat and total solids; more complete analyses give the milk sugar, casein, albumin, ash and index of refraction. The

analytical statements of the composition of milk by three prominent analysts are as follows:

TABLE 3

| | Water | Fat | Milk sugar | Casein | Albumin | Ash | Solids-not-fat | T.S. | |
|---|---|---|---|---|---|---|---|---|---|
| Van Slyke | 87.1 | 3.9 | 5.10 | 2.5 | 0.7 | 0.70 | 9.0 | 12.9 | =100 |
| Babcock | 87.3 | 3.6 | 4.50 | 3.0 | 0.8 | 0.70 | 9.1 | 12.7 | =100 |
| Blythe | 87.2 | 3.9 | 4.75 | 3.0 | 0.4 | 0.75 | 8.9 | 12.8 | =100 |

**Chemical Composition of Skim-milk and Whey.**—Van Slyke gives the percentage composition of milk skimmed with a separator as: water 90.30, total solids 9.70, butterfat 0.10, casein 2.75, albumin 0.80, sugar 5.25 and ash 0.80. His percentages for whey are: water 93.40, total solids 6.60, butterfat 0.35, casein 0.10, albumin 0.75, sugar 4.80 and ash 0.60.

**The Composition of Milk in Detail.**—From the average composition of milk it is well to pass to a consideration of its principal components and the extent to which they may be expected to vary.

**Colostrum.**—The secretion of milk is preceded by that of colostrum. For a little while before and a short time after parturition the udder yields this fluid which is small in amount, viscous, of a yellow color, a slimy appearance and a pungent taste. Its specific gravity varies from 1.046 to 1.079 and its composition, according to Engling is that given in Table 4.

TABLE 4.—THE PERCENTAGE COMPOSITION OF COLOSTRUM (ENGLING)

| | | Average |
|---|---|---|
| Water | 76.60–67.43 | 71.69 |
| Fat | 1.88– 4.68 | 3.37 |
| Casein | 2.64– 7.14 | 4.83 |
| Albumin | 11.18–20.21 | 15.85 |
| Sugar | 1.34– 3.83 | 2.46 |
| Ash | 1.18– 1.23 | 1.78 |

The function of the colostrum is not known. Some are of the opinion that it furnishes nourishment to the newborn calf, not so dissimilar from that it received through the placenta as to make the change in food violent. Others surmise that colostrum starts up digestion in the calf and that it has laxative properties that serve to rid the digestive system of meconium.

The change from the secretion of colostrum to that of milk is gradual and the time it takes to make it varies with different animals. The nature of the changes is indicated in Table 5. Usually 4 days after calving the milk may be sold as market milk, or be made into butter and cheese, but it often is 2 or 3 weeks before the milk is entirely normal.

The ordinances of boards of health prohibit the use of colostrum by forbidding the sale of milk for a considerable period before and after calving.

TABLE 5.—CHANGE OF COLOSTRUM TO NORMAL MILK (HOUDET)

| Date | Fat, per cent. | Sugar, per cent. | Soluble proteins, per cent. | Colloidal proteins, per cent. | Calcium phosphate, per cent. | Other salts, per cent. |
|---|---|---|---|---|---|---|
| Right after calving | 5.69 | 3.30 | 0.51 | 14.05 | 0.51 | 0.54 |
| 1 day after calving | 4.48 | 4.05 | 0.93 | 5.21 | 0.43 | 0.43 |
| 2 days after calving | 5.70 | 4.32 | 1.98 | 3.52 | 0.43 | 0.45 |
| 3 days after calving | 7.40 | 4.26 | 2.41 | 3.45 | 0.43 | 0.40 |
| 4 days after calving | 3.20 | 4.44 | 0.56 | 5.20 | 0.40 | 0.30 |
| 6 days after calving | 4.20 | 4.64 | 1.19 | 4.02 | 0.38 | 0.29 |
| 8 days after calving | 4.10 | 4.96 | 0.48 | 3.56 | 0.40 | 0.30 |
| 14 days after calving | 3.85 | 5.03 | 0.58 | 3.74 | 0.35 | 0.36 |

**Color of Milk.**—Milk is a yellowish-white opaque fluid having a slightly acid reaction to phenolphthalein and an amphoteric reaction to litmus; it is of sweet taste and of indefinable characteristic odor. The yellow color is derived from the fat globules and varies greatly in the milk of different breeds and also in the milk of the same cow at different seasons, generally being paler during the winter months and of greater intensity soon after the cow is put on pasture. By feeding experiments Palmer and Eckles proved that milk owes its color principally to carotin but also to xanthophylls. These pigments are not built up in the cow's body but are merely taken up in the food and subsequently secreted in the butterfat. In thin films, especially after skimming, milk has a bluish tinge but the blueness is not true color being rather in the nature of opalescence caused by tiny particles of phosphate of lime that remain undissolved in the milk plasma.

**Opacity of Milk.**—The opacity of milk is due to the casein interfering with the passage of light through the fluid.

**Specific Gravity of Milk.**—The specific gravity of the milk of individual cows, at 60°F. varies from 1.0135 to 1.0397 but in the mixed milk of a herd, rarely falls outside the limits 1.0130 to 1.034. Since butterfat is lighter than water, its increase lowers the specific gravity whereas an increase in the solids-not-fat, raises it. Hence skimming milk increases its specific gravity and watering lowers it. Consequently, taking the specific gravity is widely practised to detect this sort of tampering. As the milk may be manipulated to pass the test it serves merely as an indication. The test is usually made with a lactometer, of which there are two kinds, the Quevenne and the New York Board of Health, in common use in the United States. The latter is used less generally than the former.

**Freezing Point of Milk.**—Milk freezes at 31°F. As a can of milk freezes, the solids, except fat, are excluded from the ice so that the portion that remains unfrozen contains more casein, milk sugar and ash than the frozen, while the latter carries more fat because it rises to the top and is entangled by the ice in freezing. So samples taken for analysis from partly frozen cans do not represent the true composition of the milk.

**Electric Conductivity of Milk.**—Because of the dissolved salts that it contains, milk passes the electric current, the electric conductivity being dependent on the degree of dissociation of the salts which it carries. The resisting power of milk varies between 180 and 210 ohms.

**Refractive Index of Milk.**—The refractive index of milk varies with the composition; in normal milk the refractive index ranges from 1.3470 to 1.3515. A minimum of 1.3435 is rarely observed.

**Fat Globules in Milk.**—Under the microscope the most conspicuous elements of milk are the fat globules. They have a pearly luster and vary in size from 0.001 to 0.01 mm. in diameter averaging about 0.005 mm. and become smaller and smaller from the first milk to the strippings.

As the period of lactation advances, the number of large globules decreases and of small ones increases. Apparently the age of the cow has no relation to the size of the globules. Breed affects the size of the globules, the Holsteins and Ayrshires giving small, the Brown Swiss medium and the Shorthorn, Guernsey and Jersey large ones, but in this matter individual cows differ markedly. The fat globules are arranged in groups or clumps in the milk instead of being distributed uniformly throughout it, a matter of practical importance, for when these clumps are broken up, either by heating or centrifugalizing the milk, it does not cream well.

**Cellular Content of Milk.**—Stained milk smears under high powers of the microscope reveal numerous cells that have caused much discussion. They are now considered to be: (1) epithelial cells from the milk ducts and milk cistern; (2) mononuclear and polynuclear cells; and (3) red blood cells. At one time large numbers of these cells were believed to indicate inflammatory conditions in the udder and it was proposed to exclude from the market, milk that showed more than a certain number of cells per microscopic field, but it is now recognized that perfectly healthy animals at times shed epithelial cells in large numbers and the proposal is regarded as untenable. The presence of large numbers of polymorphonuclear cells together with long-chained streptococci is strongly indicative of mammitis and warrants an investigation of the herd or cow supplying the milk.

**The Enzymes of Milk.**—Besides the constituents already mentioned milk contains certain enzymes or soluble ferments derived from living cells. The most important of them are galactase, lipase, lactokinase, catalase, peroxidase and reductase. The origin of the ferments is not

known; some believe that they are secreted from the mammary gland while others suggest that they may be derived from the bacteria of the udder.

The enzymes are destroyed by heat; most of them withstand 140° to 149°F. for some time without material injury; most have their activity weakened between 149° and 158°F. and all of them are destroyed on relatively short exposures to temperatures between 158° and 176°F.

The function of the enzymes in milk is not known. It is the theory of some physicians that they assist in digesting milk, and they attribute the supposed difficulty of digestion of boiled as compared with raw milk to the destruction of enzymes by heat; so partly for this reason much attention has been paid to the temperature at which the pasteurization of milk is conducted.

With regard to the several chemical constituents of milk, certain facts are important.

**Water in Milk.**—Of them all, water is present in the largest proportion, for it makes up about 87 per cent. of the milk.

**Butterfat.**—Butterfat is present in milk in the form of transparent globules of which it has been estimated there are 100 million in a single drop. In freshly drawn milk the globules are suspended in the serum but on setting the milk they gradually rise to the surface and form cream.

Butterfat is not a single chemical compound but a mixture of several ethereal salts of glycerol called glycerides. It is not known how the fatty acids are combined but probably three acid radicals are united with each glycerol residue, thus:

$$C_3H_5 \begin{cases} C_4H_7O_2 \\ C_{18}H_{33}O_2 \quad \text{Glyceryl butyro-oleo-stearate.} \\ C_{18}H_{35}O_2 \end{cases}$$

For convenience the composition of butterfat is often stated as though each glyceride existed separately; that is as though the butterfat contained so much butyrin, caproin, etc. There are about 10 of these glycerides and butterfat contains about 12.5 per cent. of glycerides in combination with acids which are divided into two groups.

*Group* 1.—Non-volatile and insoluble in water: palmitic, oleic, myristic, stearic and lauric.

*Group* 2.—Volatile and soluble in water: butyric and caproic.

Butterfat on an average contains about 40 per cent. of palmytin, 34 per cent. of olein, 10 per cent. of myristin, 6 per cent. of butyrin and from 1 to 3 per cent. of other glycerides. The glycerides composing butterfat have different melting points; consequently the melting point of butterfat varies with the proportion of the several glycerides present and ranges from 85.1° to 91.4°F. The character of butterfat, also, is determined by the proportions in which the glycerides exist. Palmytin

and myristin make butterfat harder while olein and butyrin make it softer.

The churning temperature is largely determined by the relative amounts of hard and soft fats; other conditions being the same, the harder the fat the higher the churning temperature. The relative amounts of hard and soft fats are influenced by: (1) the breed, (2) the feed, (3) the period of lactation, and (4) the individuality of the cow. The butterfat of Jerseys is harder than that of the Holsteins and therefore requires a higher temperature—about 6°F.—to churn. It is inherent in some cows to produce a soft and in others a hard butterfat. With the advance of the lactation period, the proportion of hard fat increases and churning becomes difficult. By feeding certain fats the character of butterfat may be affected.

The soluble fats, of which butyrin is the most important, help to impart to milk and cream their characteristic flavor. Butyrin is found only in butterfat and so distinguishes it from vegetable and all other animal fats.

Recent investigations at the University of Wisconsin Agricultural Experiment Station have demonstrated that there is an unknown substance in butterfat, in the fat of eggs and in the fat of certain organs like the kidneys which is essential to young animals to make normal growth, but which, as far as known, does not exist in plants or in body fat in quantities large enough to satisfy them. This means that all fats are not equally valuable to animals during growth and in the opinion of McCollum, indicates that oleomargarine, since it contains a considerable admixture of the body fat of animals, is not equal in physiological properties to an equal amount of butter, although it may possess as much energy and equal digestibility.

**Proteins.—Casein.**—Casein is the most important protein of milk because it constitutes about 80 per cent. of all the proteins and because its presence makes the manufacture of cheese and other products possible. It is held in colloidal suspension in the milk serum and is not precipitated therefrom by boiling. Pure casein is white and amorphous and without taste or smell. Richmond considers it probable that casein exists in milk as a calcium sodium salt combined with one molecular proportion of tricalcium phosphate. In the souring of milk the lactic acid combines with the calcium of this compound forming free casein which on the formation of more acid takes up the acid without definite chemical combination to make the curd of sour milk. Similar changes occur when milk is treated with other acids, such as acetic, hydrochloric or sulphuric. In this way casein is precipitated from skim-milk to be manufactured into size, paints, combs and other things. Casein is also precipitated in the slime of separator and of clarifier bowls. Dilute solutions of the alkalies, such as caustic soda and ammonia, act upon

casein and its salts with acids, forming compounds that dissolve easily in water. Some of them are marketed as foods and patent medicines, such as Plasmon, Nutrose, Sanatogen, Eucasein, Galactogen, etc. One of the most characteristic properties of milk is the coagulation by the enzyme contained in rennet. It is this that makes cheese manufacture possible. The curd formed by the action of rennet is called calcium paracasein.

**Lactalbumin.**—Lactalbumin makes up 15 per cent. or more of the milk protein. It is held in solution in the milk serum but is partially precipitated therefrom by heating to 158°F. Lactalbumin is not acted on by rennet nor is it coagulated by acids at ordinary temperatures.

**Lactglobulin.**—Lactglobulin is in solution in the milk serum but exists only in traces. It is coagulated by heat at 161.6°F. but not by rennet or acids.

**Carbohydrates.—Lactose.**—The principal carbohydrate of milk is the sugar, lactose. It is the specific product of the mammary gland and is found only in milk. It has the symbol $C_{12}H_{22}O_{11}\cdot H_2O$ and is readily converted by bacteria into lactic acid,

$$
\begin{array}{ccccccc}
 & & H & & OH & & \\
 & & | & & | & & \\
H & — & C & — & C & — & COOH. \\
 & & | & & | & & \\
 & & H & & H & &
\end{array}
$$

However, the conversion is not direct for the lactose is first changed by enzymes into glucose and galactose from which the lactic acid is produced. In the ordinary souring of milk several other bodies besides lactic acid are formed by the breaking down of the milk sugar.

**Hexose Sugar.**—Jones, acting on a suggestion of Theobald Smith, has recently reached the conclusion that there is a trace of hexose sugar in normal milk and that it may come from the decomposition of lactose into galactose, or more probably, may be derived from the cow's blood.

**Salts in Milk.**—The salts of milk have not been fully studied; sodium, potassium, calcium, magnesium, chlorides, phosphates and sulphates are commonly found, as well as traces of iron, citrates and salts of organic acids. To some extent the salts are ionized. Some chemists express the results of their analyses conventionally in the form of oxides, not meaning to imply thereby that the mineral constituents actually so exist in milk. Others state them in the form of hypothetical combinations which are purely theoretical for how these constituents exist in milk is not known. On burning milk, a white ash is left which does not truly represent the mineral constituents for they are oxidized in the operation.

**Gases.**—The gases dissolved in milk are oxygen, nitrogen, and carbon dioxide; they are probably absorbed during and after milking. Decomposed milk often contains stinking gases that are derived from the breaking down of the proteins which contain sulphur.

**Composition and Flow of Milk Variable.**—There are many factors that influence both the amount of milk flow and the composition of milk. It is important to realize this for the variations are not ordinarily apparent to our senses which fact has fixed in the minds of most of us the unfortunate belief that the variations are of minor importance, that milk is milk, and that its production involves little skill and forethought. In truth, the differences in milk are considerable and the sound management of a dairy herd requires much intelligence as well as thorough training and experience.

**Effect of Maltreating Cows.**—At the outset it may be said that the milk business is founded on motherhood and that the dairy cow is a high-bred, nervous animal so that it is imperative that she have considerate treatment. Cruel and abusive usage of the animals is no part of good dairying and the farmer who curses, beats or dogs his cows is sure to have to pay for it because such acts adversely affect both the quantity and quality of milk yielded.

**Factors Influencing the Milk Flow.**—A number of things affect the milk flow. Certain breeds of cows and certain individual animals are heavy producers; it is their nature. A cow at different ages yields differently; Eckles, after careful study, reached the conclusion that on the average a dairy cow may be expected to produce about 70 per cent. as a 2-year old, about 80 per cent. as a 3-year old and about 90 per cent. as a 4-year old of the milk and butterfat that she will produce when mature. The richness of the milk remains practically constant except that after the third milking period there is a slow, gradual decline with advancing years. The size and character of the ration affects the amount of milk given and its character in less degree. Almost any change in feed has a slight temporary effect on the quality of the milk but if the ration is sufficient, the quality of the milk cannot be markedly or permanently altered in this way. Fat cannot be fed into milk but the quality of the butterfat is affected by certain feeds; for instance, linseed oil meal and gluten meal make a soft oily fat while cottonseed meal, wheat bran and some other feeds make hard fat. The milk flow is reduced in quantity by spells of heat and drouth as it is temporarily in cold snaps and if the cows are exposed to cold wet storms.

**Effect of Milking.**—The frequency and manner of milking affect both the quantity and quality of the milk. If a cow is milked three or four times a day she will produce more milk, but with greater fluctuations in the percentage of butterfat in the milk at the different milkings, than if she is milked but twice. Cows that are making a record of production

are milked four times daily. Whether frequent milking pays depends on the value of the record and commercially, on the value of the product. In Denmark, where labor is cheap cows are milked thrice daily but in the United States, it is the custom to milk but twice. When the interval that intervenes between milkings is the same, there is little difference in the morning and evening milk, but usually the period between the evening and morning milking is greater than that between the morning and evening, with the result that the morning milk is generally somewhat greater in amount and runs a little lower percentage of butterfat than the evening milk. Richmond compiled the average for 17 years of morning and evening milk where the mean intervals of milking were 10.8 and 13.2 hr. with the result given in Table 6.

TABLE 6.—PERCENTAGE COMPOSITION OF MORNING AND EVENING MILK 1897–1913 (RICHMOND)

| | Specific gravity | Total solids | Fat | Solids-not-fat |
|---|---|---|---|---|
| Morning | 1.0323 | 12.47 | 3.56 | 8.91 |
| Evening | 1.0319 | 12.83 | 3.93 | 8.90 |

In milking, the percentage of butterfat increases steadily from the first milk drawn to the strippings, so that there is considerable difference between the character of first and the last milk drawn. This is illustrated by the figures given in Table 7. Hence it is important to milk out the cows thoroughly to get the rich milk. Moreover, if this is not done, the level of production of the herd tends to drop.

TABLE 7.—AVERAGE PERCENTAGE OF CONSTITUENTS OF FOREMILK AND STRIPPINGS (ECKLES AND SHAW)

| | Total protein | Sugar | Fat | Ash | Total solid | Relative size of fat globules |
|---|---|---|---|---|---|---|
| Foremilk | 3.58 | 5.30 | 1.87 | 0.75 | 10.67 | 139 |
| Strippings | 3.38 | 5.33 | 6.28 | 0.70 | 14.86 | 215 |

**Variation in Milk from Milking to Milking.**—Eckles and Shaw found that the milk of a single cow from milking to milking is subject to the following variations. The protein varied little, for no sample varied 0.3 per cent. from the average of the animal supplying the samples and over 90 per cent. of the samples showed a variation of less than 0.2 per cent. from the average. Only exceptionally would such variations be of moment from the food standpoint. The sugar is commonly held to be the least variable constituent of milk but it was found to vary more than the protein. The milk of some animals showed a much wider

variation than that of others. About 90 per cent. of the analyses showed a variation of less than 0.2 per cent.; in certain cow's milk a variation of 0.5 per cent. was not uncommon. The butterfat varied most, the extreme being about 2 per cent. and only 56 per cent. of the samples were within 0.3 per cent. of the average; 27.7 per cent. varied between 0.6 and 0.9 per cent. and 4.6 per cent. varied more than 0.9 per cent. The investigators concluded that a sample taken from a single milking gives little indication of the quality of milk produced by any cow.

The variation in the fat content of individual cows was investigated by Anderson also. His results are given in Table 8, wherein all those animals that had a range of not more than 1 per cent. of butterfat are grouped as one class; *e.g.*, an animal testing as low as 3.2 per cent. and as high as 4.1 per cent. would range 0.9 per cent. butterfat and would be listed in class 1; class 2 would have a range of 1.8 per cent. and so forth.

TABLE 8.—VARIATION IN BUTTERFAT CONTENT OF MILK OF INDIVIDUAL COWS (ANDERSON)

| Records | Class according to range of variation of percentage of butterfat in milk | | | | | |
|---|---|---|---|---|---|---|
| | 1<br>0–1 | 2<br>1.1–2 | 3<br>2.1–3 | 4<br>3.1–4 | 5<br>4.1–5 | 6<br>5.1–6 |
| 200 7-day records, herd conditions: | | | | | | |
| Number of cows in each class | 55 | 88 | 43 | 8 | 3 | 1 |
| Percentage of cows in each class | 27.5 | 44.0 | 21.5 | 4.0 | 1.5 | 0.5 |
| 2,000 consecutive 7-day official records (*a*): | | | | | | |
| Number of cows in each class | 569 | 1,091 | 268 | 53 | 16 | 3 |
| Percentage of cows in each class | 28.45 | 54.55 | 13.40 | 2.65 | 0.80 | 0.15 |
| 600 2-day records, herd conditions: | | | | | | |
| Number of cows in each class | 446 | 121 | 28 | 3 | 2 | |
| Percentage of cows in each class | 74.3 | 20.1 | 4.6 | 0.5 | 0.3 | ... |
| 2,000 Jersey and Holstein-Friesian 2-day records (*b*): | | | | | | |
| Number of cows in each class | 1,323 | 514 | 127 | 27 | 8 | 1 |
| Percentage of cows in each class | 66.1 | 25.7 | 6.4 | 1.4 | 0.4 | 0.0 |

(*a*) A few Jersey records included; the rest are Holstein.

(*b*) 1,000 2-day semiofficial records of Jersey cows on register of merit tests and 1,000 2-day semiofficial records of Holstein-Friesian cows.

The 7-day records in Table 8 indicate that about 50 per cent. of a herd would, in 7 days, show a range of variation in butterfat of 1.1 to 2 per cent.; about 30 per cent. of them would show a range of 0 to 1 per cent.; about 14 per cent. would show a range between 2.1 to 3 per cent. and the remaining 6 per cent. would show even greater variation. On the basis of the 2-day test it would appear that about 66.66 per cent. of the animals would show a range of variation of from 0 to 1 per cent. of butter-

fat, 20 to 25 per cent. a range of 1.1 to 2 per cent. of butterfat; 5 per cent. a range of 2.1 to 3 per cent. of butterfat and the rest still wider variation.

**Individuality of the Cow and the Production of Butterfat.**—The individuality of the cow has a determining influence on the quality of milk. The percentage of fat in the milk of one cow may be high, and that of another one low, for no other reason than that it is the nature of the beasts. The tendency to produce rich milk is hereditary and does not always come from the female line; the influence of a bull of good milking ancestry in raising the fat test of the herd is well recognized and is taken advantage of by wide-awake dairymen in building up their herds. In the Dairy Record Center at Farmers Union, Ontario, there were 14 herds, seven of which had been improved by the use of purebred sires and the other seven of which had always used grade sires. The former group with 82 cows, had an average production of 7,901 lb. of milk a year, while the latter group with 84 cows had one of only 4,712 lb. The difference in production per cow of 3,187 lb. of milk divided a profit of $2,646.87 among the owners or $378.12 additional to each man.

**Effect of the Condition of the Cow at Calving.**—Eckles has shown that a cow that is fat at calving, will yield milk for 20 to 30 days, and in some cases, for as long as 4 months, that will test higher than her milk does, when she calves in poor condition. This is so, because the cow in fat, converts her body fat to butterfat. The practical significance of this is, that it pays a dairyman to bring a cow to calving in good condition, that he may reap extra profits from her high-testing milk. Another point is that it is possible to deceive the unwary by selling a cow on a butterfat test that is considerably higher than her average for the year, because it was made soon after calving.

**Changes in the Character of Milk during the Lactation Period.**—Besides the variations in the milk of the individual cow there are those of a more general character that arise from the regimen of the milk flow, the seasonal changes and the breed of the cows.

Eckles and Shaw have shown that in the course of a lactation period there are three stages.

"The first covers a period of 3 to 6 weeks and runs from the time milk secretion begins until it reaches normal. The period is characterized by high protein and ash content of the milk for 4 to 5 days, a decline in protein and fat for 3 to 6 weeks and by very large fat globules which grow small rapidly.

"The second stage begins with the close of the first, when the milk becomes normal and extends over a variable period, usually 6½ months, to the time when the milk yield begins to fall off rapidly, which usually occurs 6 to 8 weeks before the close of the lactation period. During this period the composition of the milk is uniform.

"The third stage is sometimes sharply defined and sometimes the change is gradual. It begins 6 to 8 weeks before the close of the lactation period. The

milk changes decidedly in composition. The percentage of protein and fat rises rapidly. The total protein may be one-third higher than at the middle of the lactation period but the proportion of casein and albumin remains unchanged. The butterfat changes decidedly both as to the size of the globules and chemically. Toward the end of the lactation period the cream becomes difficult and even impossible to churn. The milk of some of the cows develops an abnormal flavor and odor."

**Seasonal Variation in Composition.**—Not only does the character of milk change with the advance of the lactation period but, as Richmond has shown, it exhibits a distinct seasonal variation in quality. The year can be divided roughly into four periods thus:

1. November, December, and January; the milk is rich in fat and solids-not-fat.

2. February, March and April; the solids do not show appreciable diminution but the fat becomes less in quality.

3. May, June, July and August; the fat is low though there is a tendency for it to rise at the end of the period. In July and August the solids-not-fat are below average.

4. September and October; an improvement in quality both in fat and in solids-not-fat occurs.

**Breed of Cow and Production of Butterfat.**—That the breed of cows influences both the quality and quantity of milk produced has long been known. Table 9, compiled from the analyses of Lythgoe of the Massachusetts State Board of Health, those of the New York and of the New Jersey Agricultural Experiment Stations, gives an idea of how breed affects the quality of milk.

TABLE 9.—AVERAGE COMPOSITION OF THE MILK OF SEVERAL BREEDS OF CATTLE

| Breed | Analyst | Number of samples | Fat | Sugar | Protein | Ash | Total solids | Solids-not-fat | Ratio, protein to fat | Ratio, fat to solids-not-fat |
|---|---|---|---|---|---|---|---|---|---|---|
| Jersey | Lythgoe | 36 | 5.65 | 4.94 | 3.46 | 0.72 | 14.75 | 9.10 | 0.61 | 0.62 |
| Guernsey | Lythgoe | 28 | 5.23 | 4.84 | 3.73 | 0.75 | 14.60 | 9.37 | 0.71 | 0.56 |
| Devon | New York Ag. Expt. Sta. | 72 | 4.15 | 5.07 | 3.76[1] | 0.76 | 13.77 | 9.62 | .... | 0.43 |
| Ayrshire | Lythgoe | 27 | 4.01 | 4.88 | 2.99 | 0.76 | 12.64 | 8.63 | 0.75 | 0.46 |
| Shorthorn | New Jersey Ag. Expt. Sta. | .... | 3.65 | 4.80 | 3.27 | 0.73 | 12.45 | 8.80 | 0.89 | 0.41 |
| Dutch Belted | Lythgoe | 41 | 3.56 | 4.93 | 2.96 | 0.70 | 12.15 | 8.59 | 0.83 | 0.44 |
| American Holderness | New York Ag. Expt. Sta. | 124 | 3.55 | 5.01 | 3.39[1] | 0.70 | 12.63 | 9.08 | .... | 0.39 |
| Holstein | Lythgoe | 56 | 3.41 | 4.70 | 2.93 | 0.74 | 11.69 | 8.18 | 0.86 | 0.41 |

[1] Casein.

It is apparent that the breed of cattle has an important relation to milk quality. The total solids which in a general way represent availa-

ble nutriment are considerably greater in some of the milks than in others and the tendency is for the fat and protein to increase together from the low solids milk to the high. However, they do not increase at equal rates as the column headed protein fat ratio shows. All of these things are important to those who produce and those who consume milk and, therefore, affect the price at which it sells.

The chemical constituents of milk that have been described make up its nutrients and determine its food value. Until recently the quality of milk was judged solely by the percentage of these components that it carried but in this country about 1890 a new criterion of milk quality was introduced. Questions began to be asked about its bacterial content. Interest in this subject had been long in developing. In the period from 1857 to 1873 Pasteur, Lister and others had finally convinced people that the souring of milk was due to lactic acid bacteria and by 1881 it began to be generally accepted that infectious diseases are carried in milk. About this time the specific germs of these maladies began to be isolated so that the public became accustomed to the idea that such germs occasionally got into milk but the demonstration that market milk contained large numbers of germs of different sorts amazed people and led bacteriologists to study the rôle they played. It was soon found that bacteria did affect milk in various ways and that its flavor and keeping quality might be improved by cleanly methods of dairying and by keeping milk cold to prevent the multiplication of the germs that in one way and another got into it. Clean and cold became the watchword of progressive dairymen and of all those who were endeavoring to improve market milk. The importance of bacteriology to the milk industry was further increased by the discovery that pure cultures of bacteria might be used commercially to improve the flavor of manufactured dairy products and to make artificial buttermilk and other milk beverages which were steadily growing in popularity. So, in order to get a correct conception of the city milk problem, the relation of bacteria to dairying must be briefly considered.

**Bacteria in Milk.**—Milk as it comes from the udder generally contains but few bacteria. They are germs that have worked their way up the teat canal and have established themselves in the milk cistern and the several ducts leading therefrom. Relatively few forms are able to habituate themselves to the specialized conditions of life that continued existence within the udder imposes. The organisms that do so, constitute a very small but the only fixed part of the bacterial content of milk which, except for these types, is composed of a mixture of divers microbes from many sources. Since milk is an excellent culture medium, a large percentage of the microbes that chance to fall therein grow vigorously; consequently it has no characteristic bacterial flora but rather one that is a composite of all the germ life with which it has had contact. It is true that certain forms such as *Strept. lacticus* somewhat constantly set

up a definite series of changes in milk but even these are to be accounted for rather in the fact that they are commonly found in the surroundings with which milk comes into touch than that milk is their natural habitat.

**Classification of Bacteria Found in Milk.**—While the bacteria in milk are a heterogenous lot it is possible to separate them into groups and it is helpful to do so for it simplifies the problem they present by enabling one to clearly distinguish the useful and important organisms from those that are hurtful and those not of material interest. There are several classifications, but that in Table 10, a slight modification of that of Hastings, is believed to be as serviceable as any.

**Importance of the Various Classes of Bacteria.**—With regard to the classes as a whole it may be said that in the first, the organisms of groups 1 and 2 are most important. They are the ones that effect the ordinary souring of milk; the value of the product is in no small degree determined by which of them participates most fully in the process. The bacteria of the first group give milk a pleasant mildly acid flavor, whereas those of the second give it a sharp tang and other tastes of a less definite character. Moreover, the microbes of the second group are the particular enemies of the cheese maker, because they are the cause of gassy curds. When slovenly conditions surround the production of milk, manure and dust in which these microbes abound, will get into the milk in large quantities, and heavily seed it with the organisms. They are best controlled by scrupulous attention to cleanliness and keeping the milk well cooled. As a rule organisms of group 2 outnumber those of group 1 at the outset, but are soon overgrown by the latter. In fine, the effect of these organisms is to keep milk from putrefying; were it not for them, bacteria of the second class would find ample opportunity for development, and milk would be more perishable than it now is, and its consumption would be attended with a certain sort of danger from which it is now largely free. Bacteria of the third group have rapidly acquired commercial importance since their discovery. Lang has shown that they are particularly adapted for culturing buttermilk that is obtained from churning pasteurized cream.

The bacteria of class 2 are wholly objectionable; not only do they produce bad flavors in milk but they rot it and produce decomposition products that arouse suspicion because they are evolved from proteins. Moreover it is all but certain that some of these germs are the cause of serious intestinal disturbances in children. Their presence in milk is believed to indicate uncleanly methods of production. The pasteurization of milk at high temperature, by killing off all vegetative forms and the lactic acid bacteria in particular, may give an opportunity for these putrefactive forms to develop, which is one reason that has brought the "holder" process of pasteurizing into favor.

The microbes of class 3 betray their presence to the consumer; con-

sequently he avoids milks affected by them. They often cause producers much annoyance and some loss.

Bacteria of class 4 are unimportant. It is different with the germs of class 5. These disease-producing organisms effect no changes in milk that would warn the consumer of their presence. When they are considered on the basis of the frequency with which they occur in milk they are not impressive, but when thought of in relation to the havoc they have wreaked on customers, the worry and monetary burdens they have imposed on the dairy industry and the financial loss and ruin they have caused dairymen their consequence becomes momentous. In times bygone the very lack of knowledge of pathogenic organisms was a contributive factor to the loss. Happily, this handicap has been all but removed and effective means of protecting the industry and populace from ravages of this sort are indicated.

**Stages in the Bacterial Decomposition of Milk.**—The highest grades of milk may contain few bacteria other than the udder types but as milk is ordinarily produced for the market it contains a mixed and numerous flora, the subsequent development of which, as Hastings and others have shown, is determined by a number of factors, important among which are the character and amount of the initial seeding and the temperature at which the milk is held. The marked tendency of the lactic acid bacteria to outstrip other forms at temperatures between 50° and 67.5°F. normally causes a sequence of changes in which there are four principal stages.

**First Stage.**—The first of these is known as the germicidal stage and lasts for only a short time after the milk is drawn from the udder. Bacterial counts made at frequent intervals during the first few hours, not over 24, show progressively fewer colonies. There is much difference of opinion among bacteriologists concerning the nature of the phenomenon. Some would account for the decrease in numbers on the ground that, though milk is a favorable culture medium for many germs, it is not for all, and consequently those for which it is unsuited die off. Others believe that milk, like the blood and many body fluids, has bactericidal power, though they admit it is weak and soon lost. Rosenau and others believe that the force is not bactericidal but agglutinative; that the bacteria are not killed but are gathered in clumps from which, on the plates, single colonies arise, instead of many as there would if the clumps dispersed.

All are agreed that for a short time after milk is drawn there is a period wherein the number of germs does not increase but rather tends to fall off. It seems that at high temperature, 98°F. for instance, the action is marked but is over in 8 to 10 hr.; at low temperatures the action is not so decided but is more prolonged. The power is lost in 24 hr. or if the newly drawn milk is heated to 176°F. This latter fact has been

urged against pasteurization but the "holder" process does not attain this temperature. After the germicidal stage is passed, the bacteria increase continuously and with great rapidity. The practical importance of the germicidal period is that it may be turned to account by promptly finishing the necessary handling and cooling of the milk. In other words, milk has a temperature of about 100°F. when taken from the cow, and if allowed to stand around on a hot summer day or in a warm room will not cool down very much, so that the germicidal period may pass and rapid bacterial multiplication may actually set in before cooling and bottling the milk is begun.

**Second Stage.**—The second stage extends from the end of the germicidal period to the time of curdling. Once the germicidal period is passed, the lactic acid bacteria, group 1, increase rapidly both in numbers and relatively to the other germs which for a while may multiply, but not so fast as the lactic acid organisms. Before long, the acidity which this group of bacteria produces becomes so great that other forms are checked except that microbes of group 2, the coli-aerogenes group, may continue to develop unless the temperature of the milk is kept below 64°F. If this is done the true lactic acid organisms will crowd out practically all other organisms and increase to many millions at curdling.

**Third Stage.**—The third stage extends from the time of curdling to the time acidity is neutralized. When loppering takes place, the acidity is so high that the lactic acid germs begin to decrease and thereafter continue to fall off. *Oidium lactis*, certain moulds and yeasts which have been in the milk from the start, grow in the highly acid medium and by attacking the proteins reduce it to a neutral or alkaline condition.

**Fourth Stage.**—Final decomposition changes are effected by liquefying and peptonizing bacteria that heretofore have been inactive. They find the alkaline condition favorable for growth and assail the casein with avidity, accomplishing the ultimate decompositional changes.

**Bacterial Decomposition of Milk Usually Harmless.**—All of this must make it obvious that the development of bacteria in milk is a perfectly normal process akin to others that take place wherever organic matter is undergoing decomposition. It is evident, too, that the process is not ordinarily fraught with danger to man. The harmless lactic acid bacteria usually carry the disintegration to the point where milk becomes inedible. It is relatively exceptional for putrefying or peptonizing organisms to play the master part in milk decomposition and the germs of communicable disease gain access to milk comparatively infrequently. Still, experience teaches that there is a real danger in impure milk, and in the United States and elsewhere it is customary to spend large sums of money in seeing that adequate safeguards attend the production and marketing of milk. Of those milks that are looked upon as being unsafe, it is usual to distinguish two sorts, namely: (1) dirty and (2) infected milk.

**Dirty Milk.**—With regard to dirty milk, undoubtedly one of the chief reasons why it is held in disfavor is that the very idea of consuming food that is unclean is repugnant to most people. In some quarters there has been a tendency to make light of this feeling as being merely an appeal to the fastidious. In reply it has been well said that the eyes, the nose and the tongue were given men to use and that foods which do not appeal to the senses are depreciated in market value. However, if esthetic desire is given free rein it will lead to inordinate extravagance and perverted taste. The demand for foods put up in fancy styles in costly containers and the penchant for colored foods, bleached preserves and polished rice are illustrations of these tendencies. So with milk, the striving for cleanliness may be pushed to the point where it costs more than the benefit it yields is worth and the search for the last germ becomes a craze. Great quantities of dirty milk are consumed daily by adults without apparent harm but physicians regard dirty milk as distinctly injurious to babies because their tender mucous membranes are unfit to cope with the millions of bacteria that it contains. Rosenau gives five definite reasons why dirty milk may hurt infants, viz.:

1. "Ordinary dirt may contain yeasts that cause fermentation in the bowels, distending them with gas, producing paralysis in them and even causing death.
2. "It contains *B. subtilis* which may set up putrefaction in the intestinal tract and which has been found in excessive numbers in many cases of gastro-intestinal disturbances of children.
3. "*B. welchii* which is ordinarily found in common dirt may cause fatal diarrhea in babies and even in adults and may excite irritation and dysentery.
4. "Tubercle bacilli get into milk in cow dung and so may other germs that ordinarily do not particularly harm an adult but may overwhelm an infant.
5. "There may be toxic substances formed in milk. Dirty milk may not be poisonous but it is apt to be."

From an industrial standpoint dirty milk is highly objectionable. It yields a gassy curd and is likely to cause off flavors, consequently cheese from such milk brings low prices. Dirty milk and cream entail severe losses on the butter trade because butter made from dirty cream does not grade high in the market and so has to be sold cheap. The production of large quantities of such cream has played into the hands of foreign manufacturers who find it easy to compete with the poor butter that results from its use. The evil has become so serious that in the Middle West active efforts are being made to curb it.

**Infected Milk.**—Infected milk carries specific disease-producing bacteria and causes cases or outbreaks of communicable disease. While such milk is relatively unusual it is of immense importance and the desire to diminish the opportunities of its occurrence has had great weight in framing milk ordinances and food laws.

To summarize: the souring and spoiling of milk is not a result brought

about by anything inherent in milk itself, but is caused by germs of various sorts that are introduced to the milk and grow therein, liberating enzymes and other byproducts that disintegrate the milk. To man these organisms are not ordinarily harmful but on the contrary are on the whole protective, and are productive of various changes that are essential to the manufacturers of milk drinks, butter and cheese. It is true that some of the bacteria, the pathogenic, that develop in milk are highly injurious to man, but these organisms, though of enormous importance, should be regarded as occurring exceptionally, and should not be permitted to make one forget that other bacteria, such as those of the lactic acid and of the Bulgaricus groups, when controlled by scientific methods, are made to perform important and useful service to the dairy industry.

**Grading of Milk.**—This discussion of the chemical constituents of milk and of the changes wrought in it by bacteria must make it apparent that there is great difference in the quality of milks and hence in their value. This raises the question as to how the value of milk shall be determined. Until within a few years there has been no effort to meet this question; so long as a milk met the legal standard for butterfat and total solids and, in some places, did not exceed the limit set for bacterial count every one was satisfied. Milk was sold by the quart regardless of its quality. The effect of this was bad because the dairyman who sold clean, rich milk had to compete at equal prices with the one who sold milk that was not so clean and rich. This amounted to unfair competition because sanitation costs money and rich milk is more expensive to produce than poor milk since the cows that give rich milk do not produce as heavily as those that give milk of low test. The consequence was that the heavy-producing cows of the low-testing breeds began to displace the others and dairymen felt it a hardship to have to comply with sanitary regulations. Gradually contractors adopted the plan of paying premiums for milk testing above a certain amount, for milk produced in clean stables and for milk delivered with a low bacterial count. It became apparent that milk should be bought and sold on a quality basis so that the dairyman might produce the sort of milk he wished and the consumer might buy the sort he fancied and could afford. This has led some communities to attempt to grade milk, so that the people might buy grade A and grade B milk, just as they would buy firsts or seconds in apples and other agricultural products. The matter of grading milk is discussed in Chapter 7. Here it merely desired to point out that in establishing grades of milk there will have to be considered: (1) its nutritive value as judged by the butterfat and solids-not-fat; (2) its sanitary value as indicated by its freedom from dirt and low bacterial count; and (3) its palatability as evidenced by its acidity and flavor. Moreover, whether it comes from tuberculin-tested cows or is properly pasteurized will have to be taken into account.

Besides the ordinary milk that is used in a city, there are consumed quantities of modified milk, milk beverages, condensed milk and milk powder. These will be briefly considered.

**Modified Milk.**—The milk of every species of animal is peculiar to its kind as Table 11 indicates, and is adapted to the needs of its growing young as Table 12 shows. Those animals like the seal, dolphin and whale whose young have to develop a large amount of blubber very quickly

TABLE 11.—PERCENTAGE COMPOSITION OF THE MILK OF SOME ANIMALS

| | Water | Fat | Sugar | Casein | Albumin | Ash |
|---|---|---|---|---|---|---|
| Ass | 90.12 | 1.26 | 6.50 | 1.32 | 0.34 | 0.46 |
| Bitch | 75.44 | 9.57 | 3.09 | 6.10 | 5.05 | 0.73 |
| Buffalo | 82.63 | 7.61 | 4.72 | 3.54 | 0.60 | 0.90 |
| Camel | 86.57 | 3.07 | 5.59 | 4.01 | | 0.77 |
| Caribao | 78.46 | 10.35 | 4.32 | 5.35 | 0.53 | 0.84 |
| Cat | 81.63 | 3.33 | 4.91 | 3.12 | 5.96 | 0.58 |
| Cow | 87.32 | 3.75 | 4.75 | 3.00 | 0.40 | 0.75 |
| Elephant | 67.85 | 19.57 | 8.84 | 3.00 | | 0.65 |
| Ewe | 79.46 | 8.63 | 4.28 | 5.23 | 1.45 | 0.97 |
| Gamoose[1] | 84.10 | 5.56 | 5.41 | 3.26 | 0.60 | 1.03 |
| Goat | 86.04 | 4.63 | 4.22 | 3.49 | 0.86 | 0.76 |
| Llama | 86.55 | 3.15 | 5.60 | 3.00 | 0.90 | 0.80 |
| Mare | 89.80 | 1.17 | 6.89 | 1.81 | | 0.30 |
| Mule | 91.50 | 1.59 | 4.80 | 1.64 | | 0.38 |
| Porpoise | 41.11 | 48.50 | 1.33 | 11.19 | | 0.57 |
| Rabbit | 69.50 | 10.45 | 1.95 | 15.54 | | 2.56 |
| Reindeer | 57.80 | 17.10 | 2.80 | 8.40 | 2.00 | 1.50 |
| Sow | 84.04 | 4.55 | 3.13 | 7.23 | | 1.05 |
| Whale | 48.67 | 43.67 | ..... | 7.11 | | 0.46 |
| Wmoan | 88.20 | 3.30 | 6.80 | 1.00 | 0.50 | 0.20 |
| Zebu | 86.13 | 4.80 | 5.34 | 3.03 | | 0.70 |

[1] Egyptian Water Buffalo.

TABLE 12.—PERCENTAGE COMPOSITION OF MILK IN RELATION TO GROWTH (HAWK)

| Animal | Time in days in which the newborn doubles its weight | Protein | Ash | Calcium | Phosphoric acid |
|---|---|---|---|---|---|
| Man | 180.0 | 1.6 | 0.2 | 0.033 | 0.047 |
| Horse | 60.0 | 2.0 | 0.4 | 0.124 | 0.131 |
| Calf | 47.0 | 3.5 | 0.7 | 0.160 | 0.197 |
| Kid | 22.0 | 3.7 | 0.8 | 0.197 | 0.284 |
| Lamb | 15.0 | 4.9 | 0.8 | 0.245 | 0.293 |
| Pig | 14.0 | 5.2 | 0.8 | 0.249 | 0.308 |
| Cat | 9.5 | 7.0 | 1.0 | ..... | ..... |
| Dog | 9.0 | 7.4 | 1.3 | 0.455 | 0.508 |
| Rabbit | 6.0 | 10.4 | 2.5 | 0.891 | 0.997 |

secrete milk rich in fat while those whose offspring make rapid growth secrete milk high in protein and mineral matter.

In a sense every animal that is fed on the milk of another species is given artificial food; in fact the only common substitution that is made is that of the cow for that of the woman and even this is attended with difficulties for there are marked differences in the two milks as Table 13 shows. To lessen the troubles that arise from feeding cow's milk to babies it is often modified, or made to approach that of the woman in character.

TABLE 13.—WOMAN'S MILK AND COW'S MILK CONTRASTED (ROTCH)

| | Woman's milk | Cow's milk |
|---|---|---|
| 1. Reaction | Amphoteric (more alkaline than acid). | Amphoteric (more acid than alkaline). |
| 2. Water | 87–88 per cent. | 86–87 per cent. |
| 3. Mineral matter | 0.2 per cent. | 0.7 per cent. |
| 4. Total solids | 13 to 12 per cent. | 14–13 per cent. |
| 5. Fats | 4 per cent.; relatively poor in volatile glycerides. | 4 per cent.; relatively rich in volatile glycerides. |
| 6. Milk sugar | 7 per cent. | 4.75 per cent. |
| 7. Proteins | 1.5 per cent. | 3.5 per cent. |
| 8. Caseinogen | One-third to one-half of the total proteins. | 2.66 per cent. |
| 9. Whey products | Two-thirds to one-half of the total proteins. | 0.84 per cent. |
| 10. Coagulable proteins | Small proportionately. | Large proportionately. |
| 11. Coagulation of protein by acids and salts | With greater difficulty; curds small and flucculent. | With less difficulty; curds large and tenacious. |
| 12. Coagulation of proteins by rennet | Does not coagulate readily. | Coagulate readily. |
| 13. Action of gastric juice. | Proteins precipitated but easily dissolved in excess of the gastric juice. | Proteins precipitated but dissolved less readily. |

Modified milk was first prepared for sale, by the Walker-Gordon Laboratory Co. under the direction of Dr. T. M. Rotch, in Boston, Mass., in 1891.

It is manifestly impossible to so modify cow's milk that it will be woman's milk; all that is feasible is to make the percentages of the principal components of the two correspond and to replace the casein with whey protein. The modifications of cow's milk that are commonly made are, to reduce the protein and increase the sugar to correspond with the respective percentages of these elements in human milk. In addition, 25 to 50 per cent. of lime water is often added to increase the alkalinity of the milk and so to prevent or delay the formation of curds by

the action of rennin of the stomach, the percentage of fat is sometimes changed, the casein replaced by whey protein and sometimes a soluble starch is added to the amount of 0.75 per cent. in some such form as barley water to act as a protective colloid to prevent the formation of large casein curds. Further modifications may be made if the condition of the child seems to the physician to demand it. Modification may be made in the laboratories of certified and other milk companies but such milk is too costly for many and so modifications are made in the home according to simple rules or formulas supplied by the physician.

*Courtesy of Stephen Francisco.*

FIG. 1.—Modifying milk at the Fairfield Dairy, Montclair, N. J.

**Milk Beverages.**—The milk beverages are buttermilk, keffir, kumiss, yoghurt, matzoon and others less well known to the public. Buttermilk is the milk left in the churn in the manufacture of butter. There are two kinds, namely, that resulting from churning sweet cream and that from sour cream. The former is practically skim-milk while the latter has undergone lactic fermentation and acquired an agreeable acid flavor. Buttermilk usually carries small flakes of butter; the churning breaks up the curd and the acid alters the casein so that it is no longer acted on by acid; therefore it cannot form tough lumps in the stomach. Artificial buttermilk or cultured or ripened milk as it is sometimes called forms a large part of the buttermilk sold in the big cities. It is not made by

churning cream but by souring milk and stirring it to break up the curd. Some dealers inoculate the sweet milk with a small quantity of skim-milk that has been allowed to sour spontaneously and speak of the product as naturally soured, while others use bacterial cultures to effect souring.

Keffir is the fermented milk of the Caucasus and was one of the first fermented milks known to Europeans. Fermentation by the natives is brought about by keffir grains, small yellow warty nuggets that contain bacteria and yeast cells. These grains effect both an acid and a mild alcoholic fermentation of the milk. In this country keffir is made by adding cane sugar to milk and fermenting it in bottles with a lactic culture and bread yeast. The quantity of sugar added determines the percentage of alcohol in the finished product; the addition of 1 per cent. of sugar produces a keffir carrying about 0.5 per cent. of alcohol.

Kumiss is the fermented milk drink of the people of southern Russia, Siberia and Central Asia. Like keffir it is a mildly alcoholic acid drink that is much esteemed for invalids. It is said that the best kumiss is made in the province of Orenburg in Russia at Odessa, Samara and Ufa, in establishments under medical charge.

Yoghurt is the fermented milk drink of the Bulgars and Turks while Matzoon is that of the Armenians. These beverages are non-alcoholic and, according to Rogers, are made by inducing fermentation by *B. bulgaricus*.

All of these beverages are sold by dealers in this country. Sometimes they are put out under their proper names and sometimes under ones of the dealers choosing. These drinks are wholesome and they make a valuable addition to the American dietary. Sometimes they are taken for the health, but whenever they are so used, they should be taken as prescribed by a physician.

**Condensed Milk and Milk Powder.**—Condensed milk and milk powder form an important part of the milk supply of our cities. Bakers, confectioners and ice-cream makers use them in large quantities and in the home, condensed milk is used as a substitute for, or to supplement, the regular milk supply. These products can only be touched on here for they are more properly treated in a book on dairy manufactures.

The extent to which condensed milk enters into domestic use is not precisely known for there have been few investigations of the matter. It is used because some people prefer it to milk, because others consider it safer than milk and because most people find it a convenience since it does not have to be kept on ice. Dealers distinguish several different kinds of condensed milk but it is unnecessary for the general public to know more than two, viz., sweetened condensed milk and evaporated milk.

Sweetened condensed milk is made by adding 12 to 18 per cent. of cane sugar to milk and evaporating it *in vacuo* till the finished product

has been condensed in the ratio of 2.5 parts of fresh milk to 1 of condensed. In the process the milk is not heated high enough to kill the moulds and bacteria that are in the milk but the syrupy consistency of the finished product usually keeps them from developing. However, when the milk is diluted for use they may grow. The addition of sugar to the milk before it is condensed makes this sort of milk radically different from cow's milk.

In manufacturing evaporated milk no sugar is added. The milk is condensed in the ratio of about 2.5 : 1 and is afterward sterilized at 228° to 236°F. or at even higher temperature. This high temperature generally makes the milk sterile but it precipitates most of the albumin in the milk and very probably affects the milk sugar so that the evaporated milk, too, is quite different from cow's milk.

Milk powder is a recent comer to the market but it has found a ready market and many believe that it will have an important influence on the city milk trade. The chief difficulty that it has had to meet is that the less stable fatty acids of butterfat decompose in light and air with the production of a tallowy flavor. Powdered skim-milk does not have to contend with this obstacle and so is a success. Milk powders are not sterile but they are protected against the action of microbes by their lack of moisture. As they absorb moisture on exposure to the air they are kept in parchment-lined cartons or barrels.

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## CHAPTER II]

### DISEASES COMMUNICABLE IN MILK

Wherever men have been living together, destruction by pestilence has been going on. Of the nature of this mysterious foe man could but speculate in bewildered terror. The savage thought the sick possessed of demons; among more advanced peoples the religious looked on afflictions of this sort as visitations from God for sin. Slowly with the emerging of medicine from empiricism to a science, more materialistic explanations were advanced and belief in the supernatural gave way. In the period from 1815 to 1835 the achromatic objective was invented and the compound microscope perfected so that man had a new weapon at his disposal, one that made the enemy visible. From this time on rapid progress was made in the acquisition of exact knowledge concerning contagion. Discoveries in microbiology led to the isolation of the specific germs of diseases so that it was possible to interpret observations that were made on the mode of transmission of these maladies more accurately, but prevailing ideas had to be abandoned or considerably changed before the truth was reached. In the latter part of the 19th century the filth theory of disease obtained wide credence; it was briefly that disease germs were created out of filth or decomposing matter. Practically, it led to the cleaning up of many foul places but it did not prove sound and only in a greatly modified form is it now applied, yet testimony of the hold it took is to be found in the fact that even now the public has faith in protective health measures that have nothing besides this outgrown theory to recommend them. As this conception of the way in which contagion is engendered was given up, there was substituted the belief that it was the offspring of environment; and air, food, water and clothing were looked upon as being the sources whence it sprang. This proved to be only a part of the truth for it has been found that it is exceptional for the virus of disease to remain long alive in these things and within the last decade their importance as sources of contagion have been minimized. It is now believed that the body itself is the fountain head of infection. It is the various discharges of the organism that are dangerous and the study of outbreaks of contagion is largely a study of the way saliva, urine, feces and other excretions are circulated in the affected community. To a less extent man is infected by animals and through the bites of insects but even so the morbific principle is transferred by a more or less direct route from the sick to the well. It is the ailing beast or man that is the poten-

tial source of infection in others. Speaking by and large, disease germs do not live long outside the body; they are parasites and cannot thrive without the host. As a rule they do not live long and do not multiply in water and in foods; these serve merely as the vehicle which transfers them from one being to another and the shorter the journey the more likely is the microbe to arrive in virulent condition.

**Milk a Vehicle of Infection.**—For a long time milk escaped suspicion of being a conveyor of infection but in 1857 Dr. Michael W. Taylor traced an outbreak of typhoid fever in Penrith, England, to it. Ten years lapsed before an epidemic was again laid to milk, then in 1867 Taylor found another epidemic in Penrith, this time of scarlet fever, was due to milk. In 1872 Macnamera held an infected dairy in Calcutta, India, responsible for Asiatic cholera and in 1877 Dr. Jacob determined that a milk supply at Sutton, Surrey, England, caused diphtheria. Thus milk was implicated in the transmission of four of the principal communicable diseases. Notwithstanding the evidence that was then advanced a portion of the medical profession remained skeptical as to milk being concerned and dairymen were more than loath to accept the finding. The contentions of Taylor and the others were sustained in 1881 by a paper read by Ernest Hart before the International Medical Congress of that year, wherein he gave an account of 50 epidemics of typhoid fever, 15 of scarlet fever and four of diphtheria that were caused by milk. The paper clinched the matter. Since then so much confirmatory evidence has accumulated that it is almost universally believed that milk does carry several of the most important contagious diseases. Such milk, that carrying the specific virus of communicable disease, is called infected milk.

**Discovery of Disease Germs.**—In the early eighties discoveries were made that enabled those who believed that milk was at times responsible for the spread of contagion to speak out unequivocally, and at the same time present the case to the public in tangible form. In 1882 Koch brought out solid culture media which so advanced the technique of bacteriologists, that soon afterward the specific germs of several of the diseases were isolated and grown outside the body. The bacillus of diphtheria was discovered in 1883, that of Asiatic cholera in the same year, that of tuberculosis in 1884 and that of typhoid fever which was first observed in 1880 was grown for the first time in 1884.

So it was possible to inoculate these disease germs in milk and observe how they behave. It was found they all live in milk and with the exception of *B. tuberculosis* all multiply in it. Milk is as good food for pathogenic and many other bacteria as it is for man; they thrive in it which explains why a very slight infection is serious and why diluting the infection by adding pure milk to that which contains the germs does not materially lessen the danger of drinking such milk, after it has stood awhile, as dilution of infected water with pure does.

**Classification of Milk-borne Diseases.**—Diseases that man contracts from milk are of two classes, namely:

*Class I.*—Diseases of animal origin.

A. Definite diseases: tuberculosis, foot-and-mouth disease, Malta fever and anthrax. B. Indefinite ailments: diarrheal infections and possibly contagious abortion.

*Class II.*—Diseases of human origin: typhoid fever, paratyphoid fever, diphtheria, scarlet fever, tuberculosis, Asiatic cholera, septic sore throat and possibly others.

**Tuberculosis.**—Of all the diseases transmitted by milk, tuberculosis is the most important both because of the frequency with which it is conveyed and because of its serious nature. The tuberculosis that is derived from milk may be either of human or bovine origin. Human infection of milk is rarer than bovine and in practically every case, except conceivably from air or flies, comes from some one that is handling the milk and has the disease. A tuberculous milker who spits on his hands has every opportunity to wash the germs into the milk and the spray that is ejected in the cough of a consumptive milk handler may fall into the milk and infect it. Hess in 1908 in New York City actually isolated the human tuberculosis bacillus from a sample of market milk. However, danger from this source is relatively small and is controllable so that human tuberculosis is of less importance so far as milk is concerned than the tuberculosis that is of bovine origin.

Table 14.—Tabulation of Park and Krumwiede's Tuberculosis Cases

| Diagnosis of cases examined | Adults 16 years and over | | Children 5 to 16 years | | Children under 5 years | |
|---|---|---|---|---|---|---|
| | Human | Bovine | Human | Bovine | Human | Bovine |
| Pulmonary tuberculosis | 281 | ... | 8 | ... | 7 | ... |
| Tuberculous adenitis, inguinal and axillary | 1 | ... | 4 | ... | ... | ... |
| Tuberculous adenitis, cervical | 9 | ... | 19 | 8 | 6 | 13 |
| Abdominal tuberculosis | 1 | ... | 1 | 1 | 1 | 3 |
| Generalized tuberculosis, alimentary origin | ... | ... | ... | ... | 1 | 2 |
| Generalized tuberculosis | 2 | ... | 1 | ... | 18 | 4 |
| Generalized tuberculosis including meninges | 1 | ... | ... | ... | 25 | 1 |
| Tubercular meningitis | 1 | ... | 2 | ... | 26 | 2 |
| Tuberculosis of bones and joints | 1 | ... | 10 | ... | 7 | ... |
| Genito-urinary tuberculosis | 6 | 1 | 1 | ... | ... | ... |
| Tuberculosis of skin | 1 | ... | ... | ... | ... | ... |
| Tuberculosis of abscess | 1 | ... | ... | ... | ... | ... |
| Totals | 305 | 1 | 46 | 9 | 91 | 25 |

In 1901 Koch announced that there was practically no danger of man contracting tuberculosis from cattle. The statement was at once challenged and many bacteriologists set themselves to find out the truth of the matter. To date the reports of the English Royal Commission, of the German Commission and of Park and Krumwiede in

this country are the most valuable contributions to the subject and give fairly clear insight into the question. Koch's dictum is proven to have been based on insufficient evidence and is rejected. A summary of Park and Krumwiede's observations together with their compilations from literature of the work of other investigators including that of the English and German Commissions appear in Tables 14 and 15. There was also one case of double infection; generalized tuberculosis including meninges, 13 months; mesenteric nodes gave human type, and the meningeal fluid the bovine type. Total 478 cases.

TABLE 15.—1,033 CASES OF TUBERCULOSIS COLLECTED FROM LITERATURE BY PARK AND KRUMWIEDE

| Diagnosis of cases examined | Adults 16 years and over | | Children 5 to 16 years | | Children under 5 years | |
|---|---|---|---|---|---|---|
| | Human | Bovine | Human | Bovine | Human | Bovine |
| Pulmonary tuberculosis | 497 | 3 | 5 : 1 | ... | 25 : 3 | 1 |
| Tuberculous adenitis, axillary | 2 | ... | ... | ... | 2 | ... |
| Tuberculous adenitis, cervical | 27 | 1 | 17 | 14 | 9 | 11 |
| Abdominal tuberculosis | 15 | 4 | 1 : 6 | 3 : 5 | 3 : 6 | 7 : 4 |
| Generalized tuberculous, alimentary origin | 6 | 1 | 3 | 4 | 15 : 1 | 13 |
| Generalized tuberculosis | 27 | ... | 3 : 1 | 1 | 46 : 10 | 2 : 1 |
| Generalized tuberculosis, including meninges, alimentary origin | ... | ... | 1 | ... | 5 | 10 |
| Generalized tuberculosis; including meninges | 4 | ... | 10 | ... | 51 | ... |
| Tubercular meningitis | ... | ... | 1 | ... | 2 | 2 |
| Tuberculosis of bones and joints | 31 | 1 | 31 | 3 | 20 | ... |
| Genito-urinary tuberculosis | 16 | ... | 1 | ... | ... | .. |
| Tuberculosis of skin | 9 | 3 | 4 | 6 | 2 | .. |
| Miscellaneous cases | ... | ... | ... | ... | ... | ... |
| Tuberculosis of tonsils | ... | ... | ... | 1 | ... | ... |
| Tuberculosis of mouth and cervical nodes | ... | 1 | ... | ... | ... | ... |
| Tuberculous sinus or abscess | 1 | ... | ... | ... | ... | ... |
| Sepsis, latent bacilli | ... | ... | ... | ... | 1 | ... |
| Totals | 635 | 14 | 85 | 37 | 201 | 51 |

Mixed or double infections, 10 cases.

The two sets of cases together make a grand total of 1,511 cases and show the following results:

Adults 16 years and over, 940 human; 15 bovine; percentage bovine 1.5.
Children 5 to 16 years, 131 human; 46 bovine; percentage bovine 26.0.
Children under 5 years, 292 human; 76 bovine; percentage bovine 20.6.
Mixed or double infection, 11.

These figures indicate that about a quarter of the cases of tuberculosis in children under 16 years of age is due to infection with the bovine type of bacillus and that the number of cases of bovine origin among adults is very small.

The relation of tuberculosis of bovine origin to tuberculosis in general, is hard to define. It is estimated that in the United States tuberculosis is the cause of 9 per cent. of the deaths and in Germany 12 per cent.

If only 1 per cent. of these in this country were due to bovine infection it would mean a loss of 1,600 lives a year but the percentage is believed to be considerably greater, being placed at 7 per cent. by some. It is recognized that in all probability practically none of the pulmonary tuberculosis is due to bovine bacteria and that were all bovine tuberculosis stamped out, the tuberculosis problem would be simplified but not greatly reduced in magnitude. Japan and other countries, that are not consumers of milk and dairy products, have a great deal of tuberculosis. On the other hand, it is becoming patently evident that tuberculosis of bovine origin is largely responsible for surgical and abdominal tuberculosis, especially among children. Furthermore, it is to be remembered that practically all bovine bacteria isolated from infections in man were acquired from the ingestion of dairy products.

**Nature of Tuberculosis.**—Tuberculosis like other diseases has three well-marked stages, the prodromal or incubating period, the period of sickness, and the period of recuperation or recovery. It differs from many other infectious diseases in that all of these periods may be prolonged. It is likely to be slow and insidious in sharp contrast to such diseases as smallpox and measles which commonly develop within 2 weeks after exposure and are soon over. In some diseases like diphtheria and tetanus, the causative germs elaborate poisons called toxins that cause the death of the patient unless they are neutralized in some manner, but in tuberculosis the germs do not kill in this way. They imbed themselves in the tissues of an organ and by their growth injure it, often eventually destroying it and so, if the organ is a vital one, cause death. Often the first warning given by the disease is the impairment of the function of some organ which makes the victim feel sick.

After the germs have secured lodgment they grow and produce the excrescences called tubercles which are so characteristic that they have given the name tuberculosis to the disease. The tubercles are soft and cheesy or hard and calcified; they may remain isolated or may be confluent and form a mass of corruption. In several ways the body tries to rid itself of the invading organisms. One defense is to surround the diseased spot with a thick wall of fibrous tissue thereby isolating it and arresting its development. Where this is successful the progress of the disease is stopped, and it may stay arrested for years during which time the animal may be a useful creature, but often the attempt to form a wall is abortive or only temporarily successful, the germs breaking through the defense and spreading the disease. Sometimes the only organ involved is that first attacked, in which case the disease is said to be localized but often it spreads to other organs and sets up a generalized infection. Sometimes the tubercles are scattered widely in the form of little hard bodies like millet seeds and give the form of the disease known as

miliary tuberculosis or galloping consumption the progress of which is very rapid. Sometimes the serous membranes covering the lungs or intestines become seeded with these grains giving rise to a condition known as "pearl disease." Neither the rate of progress of tuberculosis nor the time the sickness will last can be predicted; these depend upon the stamina of the host, the virility of the bacteria, the massiveness of the original infection, and other factors imperfectly understood.

So long as the disease is confined to bones, glands and other structures that do not communicate with channels leading to the exterior of the animal, it is said to be closed and the animal is regarded as being unable to infect others, but when structures such as the lungs, liver, gall-bladder, kidneys, urinary bladder, udder, and genital organs, that do lead without the animal, are invaded the creature becomes a highly dangerous source of contagion to susceptible beasts and to man, for under such conditions living germs are scattered broadcast. In this state the animal may reinfect itself, as for instance, by inhaling sputum that is raised but not coughed out, thus establishing new diseased foci in the lungs or by swallowing such sputum it may set up infection in the viscera or other parts of the body.

**Entrance of Tuberculosis Germs into the Body.**—Tuberculosis germs gain entrance to the body in two principal ways: by being breathed in and by being swallowed with food. There is dispute as to which of these modes of infection is the commoner; that neither is infrequent seems probable.

**Passage of Tuberculosis Germs from the Body.**—The germs of tuberculosis are expelled from the body in the sputum, the urine and feces, and in discharges from the genital organs. The sputum is infectious when the lungs are diseased and so the droolings and the fine spray that is ejected when the animal coughs spread the disease. Thus the sick cow may lick herself and other cows or may "nose" them and so distribute the germs. Coughing is likely to spread contagion to other animals especially to those confined in adjoining stalls. In fact the pestilence is scattered wherever the infected sputum falls, in the feed, mangers, salt boxes, watering troughs, on floors and in pastures. Tubercle bacteria are expelled in the urine when the kidneys or urinary bladder are diseased, and by these discharges the flanks of the animals and the ground are infected. The feces are infected when the animal has intestinal ulcers, when the liver or gall-bladder is diseased, or the lungs are so that infected sputum swallowed by the animal is passed. On some farms manure is piled where cows can get at it and mouth it and thus infect themselves. Manure from a tuberculous animal may infect whatever it touches including the exterior of the animal itself. So the hair and dirt that falls from such a creature into the milk infects it; consequently a cow without tuberculosis of the udder may infect milk.

**Infection of Milk by Germs of Tuberculosis in the Feces.**—That milk might be infected with tuberculosis by contamination with the manure of cows afflicted with the disease, was pointed out by Sedgwick and Batchelder in 1892 in their paper on the bacteriological examination of the Boston milk supply but the gravity of the menace was not appreciated till Shroeder and Mohler in 1906 emphasized its importance.

Efforts have been made at Washington, at the Cornell, Minnesota, Nebraska and Illinois Agricultural Experiment Stations and by the English Royal commission to determine the frequency with which tubercular cows pass the germs of the disease in their feces. In the six instances 147 animals were studied and 16 of them were proven to be passing the bacilli. Eleven of these reactors were slaughtered and every one was badly tubercular; they all had abscesses of the lungs, seven had ulcers of the intestines and six tuberculosis of the liver. Of the five animals not autopsied one was manifestly tubercular and the others were not. From this series of experiments it seems evident that animals in advanced stages of tuberculosis pass tubercle bacilli in their feces and that animals seemingly in good health may do so.

**Frequency of the Infection of Milk with Tuberculosis.**—The milk of tuberculous cows is likely to contain the germs of the disease and so unless heated to a high enough temperature to kill them is a potent factor in spreading the disease, not only among the calves and swine that may be reared on it but to man himself. In discussing the frequency with which milk carries tuberculosis germs, there are to be considered: (1) milk from cows having tuberculosis of the udder; (2) milk of tuberculous cows without such a lesion; and (3) market milk.

There is no question at all as to whether cows with tuberculous udders yield milk that carries the germs. Authorities are agreed that in all but very rare cases such milk contains enormous numbers of the germs in a highly virulent condition. A cow with a tuberculous udder is such an ugly menace that she should be sent to the shambles at once.

As to whether the milk of tuberculous cows whose udders are unaffected is infectious or not there is considerable difference of opinion. Briscoe and MacNeal record tests of the milk of 748 tuberculous cows without recognizable disease of the udder, and of the samples tested in various ways 131 proved positive. However, many of the positive results were secured by early investigators who doubtless did not take elaborate precautions to prevent the milk becoming infected from external sources. In the later important work Ostertag at Berlin in 1899 examined the milk of 50 cows finding the milk of 49 negative and one doubtful and in 1901 that of 18 cows was all negative. Müller in Germany, in 1899 tested the milk of nine cows finding it all free from the germs and Smit at Rotterdam in 1909 likewise got negative results from the milk of 35 cows. On the other hand, DeJong at Leiden in 1908 found that

three out of 10 cows that he examined were passing tubercle bacteria in the milk and also the British Royal Commission found two out of four cows with sound udders to be passing the germs in the milk.

Market milk presents still a different aspect because the germs of tuberculosis may be derived not only from cows with tuberculosis of the udder but from any animal that has an open case, and even from human sources. Consequently such milk might be expected to be slightly infected somewhat constantly. Table 16 presents the important European and American studies of the frequency of infection of market milk with tubercle bacilli.

TABLE 16.—TUBERCLE BACTERIA IN MARKET MILK (*a*)

| Date | Place | Investigator | Samples examined | Number positive | Percentage positive |
|---|---|---|---|---|---|
| 1899 | England | Macfayden | 77 | 17 | 22.1 |
| 1904 | Germany | Müller(*b*) | 1,596 | 97 | 6.2 |
| 1904 | Germany | Beatty(*b*) | 272 | 27 | 10.0 |
| 1898 | Liverpool | Delepine | 12(*a*) | 22 | 17.6 |
| 1897 | Liverpool | Hope | 228(*b*) | 12 | 5.2 |
| 1900 | London | Klein | 100 | 7 | 7.0 |
| 1893 | St. Petersburg | Scharbekow | 80 | 4 | 5.0 |
| 1900 | Kiew | Pawlowsky | 51 | 1 | 2.0 |
| 1900 | Krakow | Bujwid | 60 | 2 | 3.3 |
| 1900 | Naples | Marconi | 14 | 7 | 50.0 |
| 1898 | Berlin | Petri | 64 | 9 | 14.0 |
| 1900 | Berlin | Beik | 56 | 17 | 30.3 |
| 1898 | Schev. Gueund | Ott | 27 | 27 | 11.1 |
| 1898 | Konigsburg | Jaeger | 100 | 7 | 7.0 |
| 1908 | Leipsic | Eber | 210 | 22 | 10.5 |
| 1905 | Rotterdam | Smit | 567 | 14 | 2.7 |
| 1906 | Rotterdam | Smit | 1,584 | 45 | 2.8 |
| 1908 | Washington | Anderson | 223 | 15 | 6.7 |
| 1909 | Louisville | Field(*c*) | 119 | 46 | 29.5 |
| 1909 | New York | Hess | 105 | 17 | 16.2 |
| 1909 | Philadelphia | Campbell | 130 | 18 | 13.8 |
| 1910 | Chicago | Tonney | 144 | 15 | 10.5 |
| 1910 | Rochester | Goler | 237 | 30 | 12.6 |

(*a*) Compiled from table of BRISCOE and MACNEAL and from other sources.

(*b*) Work done for East Prussian Herd Book Society with the object of detecting and removing cattle with udder lesions.

(*c*) Tests made at the time the city was starting a crusade against slop dairies and the figures are probably too high to be applied to the average country herd supplying the city. DR. B. C. FRAZIER states that in the tuberculin tests of between 600 and 1,000 cows in 1916 but three reactors were found.

Of the Washington investigation it may be said that tuberculin tests of herds supplying the city has shown 214 reacting animals out of 1,147

tested or 12.6 per cent. and tests by the District Health Department upon 51 herds likewise supplying the city detected 160 reacting animals out of 1,095 tested or 15.1 per cent. These figures were regarded as low because the herds tested were believed by their owners to be largely free from the disease. The samples of milk tested by animal inoculation showed that 11 out of 102 dairies or 10.7 per cent. were supplying milk that contained tubercle bacteria.

The New York investigation of 1909 was undertaken to determine first, what percentage of the milk of New York carried tubercle bacteria; second, what percentage of tubercle bacteria in the milk are of human and what of bovine origin; and third, what effect the infected milk has upon children. The samples were taken from 40-qt. cans in grocery stores, dairies and large milk plants in various quarters of the city and every sample was tested both by microscopical examination and animal inoculation. Out of 105 successful tests 17, or 16.2 per cent., gave positive results. Eight cultures were isolated and studied to determine whether the bacteria were of the human or bovine variety; it was found that one was the former and seven of the latter type. Ten of the 17 milk dealers whose milk gave positive tests let their children have the milk to drink raw. These 10 dealers had 18 children, 16 of whom were tested with tuberculin with four reactions.

**Length of Life of Tuberculosis Germs Outside the Body.**—To determine the length of time tuberculosis germs live outside the animal, many studies have been made. Sunlight and desiccation are the two agents that nature uses most effectively to destroy microbes. Direct sunlight kills tuberculosis germs in a few hours or even in a few minutes when a culture is spread out in a thin film on glazed paper or glass slips. The organisms live 10 or 15 times as long in diffuse as in direct light. There are many difficulties in determining the length of time bacteria will withstand drying and the many bacteriologists that have investigated the subject experimentally have obtained conflicting results. The work that has been published since 1900 seems to indicate that the germs naturally placed will withstand drying for from a week to a couple of months.

Moore says that tuberculosis germs, expelled in the saliva on pastures where direct sunlight reaches them, soon perish; that in fecal matter where they are somewhat protected from sunlight they will live longer, that in mangers in dark damp stables they will live a considerable time and that such stables are thought to remain infected several months.

**Mode of Infection of the Herd.**—As to how herds are infected many ways may be conceived but practically only two are important: the disease may be introduced (1) with certain feeds, particularly with skim-milk or whey returned unsterilized from creameries and cheese factories, or (2) by buying the disease through the purchase of diseased stock.

As illustrative of the danger of this first mode, the data collected by Russell are convincing; they appear in Table 17.

TABLE. 17.—THE RELATION BETWEEN UNSTERILIZED SKIM-MILK FROM CREAMERIES AND BOVINE TUBERCULOSIS (RUSSELL)

| Creamery | Number of herds tested | Number of herds reacting | Number of animals tested | Per cent. of reacting animals | Results of slaughter | |
|---|---|---|---|---|---|---|
| | | | | | Number passed | Number condemned |
| Medina | 36 | 33 | 784 | 34.5 | 105 | 123 |
| Oak Park | 24 | 14 | 429 | 24.0 | 34 | 61 |
| Group A[1] | 66 | 42 | 1,249 | 8.5 | ... | ... |
| Group B[2] | 12 | 8 | 218 | 10.0 | ... | ... |

[1] Group A comprises seven creameries immediately adjacent to Medina and Oak Park.

[2] Group B comprises four creameries near but not contiguous to Medina and Oak Park.

The reacting animals in the herds of the Medina and Oak Park creameries were nearly all raised on the farm and were fed skim-milk returned in an unsterilized condition from the two creameries whereas the reactors in groups A and B were mostly acquired by outside purchase.

The buying in of tuberculosis has been very common in the past. Some dairymen have been so blinded to aught but immediate gain, as to purchase cows they knew were diseased, carrying them through a milking period and thereafter sending them to the block; others unaware or unable to appreciate what they were doing have brought diseased animals into their herds with the result that as the newcomers developed open cases and became germ scatterers others succumbed. In truth, cows with open cases are the most effective disseminators of the disease. Experience has proven that bovine tuberculosis is most prevalent in districts supplying the city milk trade. Cows are pushed to the limit of production and farmers feel that they must sell every drop of milk; consequently calves are not raised, so that replacements and additions to the herds are made by purchase. This constant movement of cattle from one herd to another has had the effect of spreading the disease more rapidly than under the natural condition where the herd practically maintained itself.

**The Diagnosis of Tuberculosis.**—The question arises, how it may be determined whether or not a dairy animal has tuberculosis? Four methods of diagnosis are in use, namely: (1) microscopical examination of excised tissue which is obviously of limited application; (2) microscopical and bacteriological examination of discharges of various sorts from the suspected animal, procedures of wider use but time-consuming and often

uncertain; (3) physical examination; and (4) the tuberculin test. The great bulk of testing is done by the last two methods.

**Physical Examination.**—The detection of the disease by physical examination is based on the fact that as the disease progresses certain symptoms become manifest to the trained observer. Of course, in time these become obtrusively evident but at first they may be difficult to detect as must be apparent when it is remembered that many of the organs commonly attacked are impossible to get at. A persistent cough, enlarged glands, tendency to be in heat frequently and alternating constipation and diarrhea make even the layman suspicious but these signs are also symptoms of other diseases and may mislead any but the professional. Moore gives the impression that physical examination is used a great deal more in Europe than in the United States and that veterinarians there are far more expert in this sort of diagnosis than Americans are. Some hold that frequent and thorough physical examinations will keep a herd free from open cases of tuberculosis and that thereby the spread of the disease may be controlled, with the result that the infected market milk may be kept down to a minimum quantity.

As evidence against this contention the number of positive results in the "control" samples of Sheffield, England, may be cited. Savage says that samples are taken of the milk coming to the city from outside sources and are bacteriologically examined and that when tubercle bacteria are found, the farms supplying the samples are visited by a skilled veterinary inspector who, in case no cows are found having tuberculosis of the udder takes "control" samples to check up the work of the veterinarian. Therefore, such samples are of the mixed milk of herds of cows without clinical signs of tuberculosis. Table 18 shows the results of such examinations.

TABLE 18.—REPORT ON "CONTROL" SAMPLES BY MEDICAL HEALTH OFFICERS OF SHEFFIELD (SAVAGE)

| Year | Number of control samples taken | Number tuberculous | Percentage tuberculous |
|---|---|---|---|
| 1902 | 1 | .. | .... |
| 1903 | 7 | .. | .... |
| 1904 | 11 | 3 | 27.3 |
| 1905 | 17 | 6 | 35.3 |
| 1906 | 8 | 1 | 12.5 |
| 1907 | 39 | 8 | 20.5 |
| 1908 | 62 | 7 | 11.2 |
| 1909 | 56 | 8 | 14.3 |
| 1902–09 | 201 | 33 | 16.4 |

So, on an average in 16.4 per cent. of the samples, tubercle bacteria were

found in the herd milk produced by cows passed as free from udder tuberculosis by skillful veterinarians especially on the lookout for evidences of the condition.

How the physical examination in this country works out is exemplified by the experience of Montclair, N. J. (see Table 25, p. 49). For 8 years prior to the enforcement of the requirement that milk should either come from tuberculin-tested cows or be pasteurized, the herds supplying the town were subjected annually to a physical examination by veterinarians paid by the dairymen. When the tuberculin test was applied to 15 of these herds all but one contained tuberculous animals, about 25 per cent. of the animals being reactors. It is stated that at the time of testing, in only a few cases could the disease have been discovered by physical examination. As autopsies were not performed on the reactors, it is not known how many of the herds had animals with open tuberculosis. To be at all effective, physical examinations must be both frequent and thorough; consequently some dairymen object on the score of cost, and it is probably true that in the United States adequate physical examinations would be more expensive than tuberculin testing.

**Tuberculin.**—Tuberculin, discovered by Koch, in 1890, has been used as a diagnostic agent for tuberculosis in cattle since 1891 and has been adopted everywhere for this purpose. It is a liquid, usually a glycerinated broth, that contains products thrown off by tubercle bacilli grown in it. These products cause the temperature reaction that identifies a tubercular animal that has been injected with tuberculin. There are no tubercle bacilli in tuberculin because in the process of preparation they are killed by heat and removed by filtration.

According to Moore the technique of preparing tuberculin is as follows:

"The tubercle bacteria are grown in pure culture at about 99.5°F. on a liquid medium consisting of beef tea containing peptone (about 1 per cent.) and glycerin (from 5 to 7 per cent.). In some laboratories a little acid potassium phosphate is added. This glycerinated, peptonized broth is put in flasks, usually in from 100 to 250-c.c. amounts. After it is sterilized it is inoculated with tubercle bacteria by transferring some of the growth from a young culture to the surface of the liquid in the flask. The bacteria do not grow in the depth of the liquid but form a membrane over the surface. After the cultures have grown long enough, from 4 to 10 weeks, the flasks are placed in a water bath and heated to from 121° to 149°F. for about 2 hr., after which they are boiled. After boiling, these cultures are filtered through ordinary filter paper to remove the mass of bacteria. The filtrate is then evaporated over a water bath to the desired consistency and is then filtered through a porcelain Berkefeld filter. In some laboratories it is filtered through the porcelain filter before it is concentrated.

"The original Koch tuberculin was evaporated to one-tenth the volume of the culture liquid, that is, 100 c.c. of the culture was evaporated to 10 c.c. and a little carbolic acid (one-half of 1 per cent.) added to the filtrate to preserve it. It is kept in glass-stoppered bottles.

"It has been found that either the human or bovine variety of tubercle bacteria can be used in the preparation of tuberculin. Occasionally a culture of tubercle bacteria is found that will not produce satisfactory tuberculin. The active principle of tuberculin is believed to come from the bodies of tubercle organisms that have become macerated in the culture medium."

The tuberculin above described is the original tuberculin of Koch and is commonly marked T.O.; he later prepared a new tuberculin from the bodies of unheated tubercle bacteria that is usually marked T.R.

The dose of tuberculin is graduated to the size of the animal. That given an adult animal of medium size is 0.25 c.c. of the T.O. That put up in the laboratories of this country is so diluted that 2 c.c. is a dose.

There are three different ways of using tuberculin to detect tuberculosis in cattle and they are distinguished as (1) the subcutaneous test, (2) the intradermal test or von Pirquet reaction and (3) the ophthalmic test.

**Subcutaneous Test.**—In the subcutaneous test the cattle are stabled, watered and fed in the usual place and way. Since the temperature of cattle varies, it is taken three times at 2- or 3-hr. intervals, previous to injection. At 8 or 9 p.m. the tuberculin is administered beneath a fold in the skin, commonly at the shoulder. Seven hours after injection the taking of the rectal temperatures of the animals is commenced and observations are taken thereafter every 2 or 3 hr. until the twentieth hour after injection. The usual reaction consists of a rise in temperature beginning about the sixth or eighth hour after injection and continuing several hours. The normal temperature of the cow is 101 to 102. 5°F. and the tuberculin causes a rise of from 1 to 5°F. The interpretation of the thermal reaction requires experience and good judgment. Some testers regard a rise of 1.5° or 2° above the highest temperature recorded prior to injection as positive. Moore, on the basis of many autopsies, believes that a slight rise may represent a reaction; that if the curve is well-marked, the cases are suspicious when the maximum temperature ranges from 103.5°F. down to 103° or even to a few tenths of a degree less and that on slaughter 40 to 60 per cent. of these animals show tubercular lesions but that 104° is the minimum at which one can make a sure diagnosis.

The tuberculin test has certain limitations. It will not detect tuberculosis in the prodromal stage, or in arrested cases, or sometimes in very advanced cases and it may be vitiated by "plugging" that is by dosing the animal with tuberculin previous to the test. Also poor tuberculin or that which is too old is worthless. Since the test will not pick out the animals coming down with the disease, nor those in which it is inactive, it is imperative to retest a herd after 6 months or at most a year. Failure to do so has led to disastrous results. The fact that the test does not demonstrate animals of these classes has an important bearing on the slaughter of animals in tainted herds and on the purchase of non-reacting

animals from infected herds. The value of tuberculin as a guide in purchasing is very great but experience has shown that when 50 per cent. or more of the cows react, a considerable number of the animals that do not have arrested tuberculosis; consequently purchasers of non-reactors must retest at frequent intervals. Failure to understand this has led to costly experiences on the part of purchasers and to unjust charges of dishonesty against the testers.

A shortcoming of the tuberculin test is that it gives no idea of the severity of the case. So, when animals are opened up, often only an inconsequential lesion is found. In other words the test is regarded as being too delicate by those who would exclude only open cases from their herds. That the testing is a searching one is probably most fortunate and it is likely that in the end less loss results from the removal of animals to which a period of usefulness still remains than would occur if the test was of such a character as to grade the cases.

Of the animals which give good reactions about 98 per cent. show lesions on slaughter and it is probable thorough examination of inaccessible parts would increase this percentage but when the animals that for reasons which have been given do not react are considered too, the percentage of accuracy of the test is only about 85 per cent., so that the building up of a tuberculosis-free herd is a matter not of a year or two but of 4 to 8 years.

**Tuberculin Test as a Criterion for Excluding Milk from the Market.**—All of these imperfections have their bearing on the value of the tuberculin test as a measure to secure the public health by shutting tuberculous milk out of the market. The Supreme Court of the United States, the Supreme Court of New Jersey and the courts of other States have declared that the proper authorities may require the tuberculin test to be applied to herds supplying milk to the communities within their jurisdiction. Ordinances making the test compulsory are in force; they usually make it optional whether the dealer shall test his herds or pasteurize the milk. The question arises whether such ordinances are wise. In the first place it should be recognized that the enactment of such an ordinance has a very great educational effect. Producers and consumers alike are made alive to the problem of tuberculosis as a whole and in particular as to the relationship of dairying thereto. The question is thoroughly discussed and usually all concerned are gainers from the agitation. The enforcement of an ordinance helps the community to which it applies by reducing the number of tuberculous cattle but in this respect the amount of good accomplished depends in no small measure on the spirit in which the farmer meets the ordinance. His knowledge of the herd and a belief on his part that the removal of reactors is for his ultimate benefit are all but essential to a thorough weeding out of diseased animals. But because of faults inherent in the test itself, it is highly improbable that even a

good ordinance, by the tuberculin test alone, can do more than give a high degree of protection from the tuberculous cow. Ordinances that are defective in that they do not provide for semiannual or at least annual retests of the herds, or that do not require the application of the test to replacements and additions to the herd in the interval between tests, or that fail to provide for notification to the proper authorities of what final disposition of reactors is made, are likely to fall far short of giving adequate protection and in some cases to lull the consumer into a sense of false security. This is apt to be almost certainly the case, if funds to insure the enforcement of the ordinance are not forthcoming. In large cities where the herds are many and widely dispersed the expense of seeing that such a law is complied with is very considerable. Moreover, when such ordinances are first put into practice a concentration of losses is all but sure to fall upon the farmer. In small communities that have required the tuberculin test there has not always ensued a rise in the price of milk but it is claimed that should large cities require it there would follow an increase of 1 ct. a quart. The opponents of the tuberculin test also point out that it protects against one disease, tuberculosis, only whereas a safeguard against all the diseases that may be transmitted by milk, is furnished by the "holder" process of pasteurization. Furthermore it is contended that inasmuch as many city dealers are already supplied with pasteurizing machines, since it has been found necessary to pasteurize milk shipped from distant points in order to preserve it, there will be no necessity for increasing the price of milk if compulsory pasteurization is substituted for the tuberculin test.

There is considerable merit in this argument but those contemplating choosing pasteurization in preference to the tuberculin test should not for an instant forget that pasteurization is done by machinery under human direction, that both are liable to failure and that both need supervision. Pasteurizing machinery without automatic continuous temperature-recording devices is worthless while the records, the machinery and the finished product demand frequent, rigid and efficient inspection to keep the process from degenerating into a fraud.

**The Intradermal Test.**—The intradermal test is used exclusively in Missouri by the State Veterinarian in State work but for interstate shipments the subcutaneous test is used because the intradermal test leaves no record, and has not been officially recognized by the Bureau of Animal Industry. The intradermal test is used officially in the Territory of Hawaii, and in Delaware and California is accepted, if made by an approved veterinarian. In the last-named State members of the Experiment Station staff are of the opinion that the subcutaneous test yields unsatisfactory results on young calves, on wild range cattle and on dairy stock in the hot season in some of the interior valleys. In California, then, Ward and Baker and also Haring and Bell have used the intradermal

test extensively. The latter two authors have made 4,926 tests, including retests on 4,001 head of cattle of which 1,614 reacted, the results being checked by 1,000 subcutaneous tests and 341 autopsies. They consider that if a 5 per cent. or stronger solution of alcoholic tuberculin is used and the tests are performed by experienced operators, the results are of equal accuracy to those obtained by the subcutaneous method and are obtained with economy of time and materials. They do not recommend the test for unskilled practitioners.

Injection is done with a hypodermic syringe having a needle of 25 or 26 gage and a point $\frac{3}{16}$ in. long, and is best made into one of the folds of the skin underneath the base of the tail. The application of disinfectants to the point of injection should be avoided for they are likely to produce swellings that may be mistaken for the reaction. A positive result is indicated by a thickening of the subcaudal fold or by the appearance at the point of injection of a sensitive swelling varying in size from that of a small pea to that of an orange. Small indurations about the size of the head of a parlor match frequently occur in normal non-reacting cattle at the point of inoculation but anything larger, that persists for 72 hr. should be considered a positive reaction. A recognizable reaction may be present on the sixth hour after injection but usually it is first clear about the twelfth hour and continues to increase in size till the forty-eighth hour. Delayed reactions that do not appear until the nineteenth hour have been noted and in some instances early reactions disappeared before the forty-eighth hour. To make certain of every case two observations must be made, preferably at the thirty-sixth and seventy-second hours. If only one observation can be made, it should be on the seventy-second hour. Haring and Bell found that the injected cattle frequently, but not always, exhibited a well-marked thermal reaction. Thus in 273 cattle from seven herds, 153 reacted locally and of these 130 reacted thermally, but none reacted thermally which did not locally. It has been their experience that the cases which fail to react thermally either to the intradermal or the subcutaneous tests have usually been found on autopsy to have small encapsulated lesions. In the course of their work they have encountered 35 cases that showed a thermal reaction to the subcutaneous test but failed to give a local reaction with the intradermal. One of these cases was autopsied and showed a few active tuberculous lesions. The failure of this and the other 34 cows to react locally is accounted for on the theory that a local reaction is weakened when it occurs simultaneously with a thermal reaction though it is pointed out that there were many cases where both reactions were well marked.

Opinions as to the relative accuracy of the subcutaneous and intradermal tests are divided, and more data needed before the question can be decided. Those that have used the latter test extensively incline to the belief that in skilled hands it yields results of equal value to those yielded

by other tests and they regard it as being more easy to apply because the necessity of taking temperatures before and after injection is obviated. Haring and Bell find that like the subcutaneous test the intradermal test does not always react in advanced cases but think that it will detect more arrested cases and consider that the results of retests compare favorably with those obtained by the subcutaneous method under similar conditions. Repeated intradermal injections cause the animal to lose sensitiveness to the test. An alcoholic tuberculin should be used in making the test and the lack of a standard tuberculin of this sort is an impediment it has to meet.

**The Ophthalmic Test.**—The ophthalmic test was first used on cattle in 1907. McCampbell and White and others find that it has some value for diagnosing tuberculous cattle. A tuberculin that does not contain peptone, glycerin, or carbolic acid as T.O. tuberculin does, must be used. To apply it the head of the animal is turned at an angle and 1 to 2 drops of tuberculin are dropped from a hypodermic syringe right on the eyeball. Then the closed eye is slightly massaged for several seconds. Reactions usually set in by the eighth hour but may be delayed so that observations should be made in the twelfth, eighteenth and twenty-fourth hours. A positive result is indicated by watering of the eye, reddening of the conjunctiva and dropsical swelling of the lid. A purulent exudate accumulates later, at the inner corner of the eye and usually runs down into the face. This dries up and drops off in a few hours. There is no thermal reaction. The objection has been raised that decision as to whether or not the test is positive depends on the opinion of the observer which in slight reactions is liable to error. Other objections are, that rain may wash out and obscure evidence of the reaction; long hay may wipe off the exudate and exposure to wind and to bright sunshine causes unsatisfactory results. The test is satisfactory only when the cattle can be kept tied under shelter for at least 16 hr. Haring and Bell with tuberculin from the Bureau of Animal Industry tested 139 cattle known to be reactors and obtained positive results in every case. They record one case when on autopsy a cow that failed to react either to the subcutaneous or the intradermal test but did react to the ophthalmic test, proved to be tuberculous.

One reaction probably inhibits another for a period of 6 weeks to a year and is most pronounced in animals that have not been tested recently with tuberculin; however, cattle that have been so tested will give the reaction but with reduced intensity.

**Value of the Tuberculin Test.**—In describing the several methods of using tuberculin the attempt has been made to set forth plainly the limitations it has as a diagnostic agent but it should be clearly understood that in spite of them all it is wonderfully accurate and that when properly used it is a very effective weapon wherewith to fight this terrible scourge

that lays heavy toll on both man and beast. One of the great advantages it possesses is that it has no ill effect whatever on the health of cattle that are not affected with tuberculosis, either when a single injection is given or when it is applied repeatedly as in using it in the eradication of tuberculosis from a herd.

**Results of Tuberculin Testing.**—In the United States and Europe tuberculin testing of cattle has been widely used with the result that dairy cattle have been shown to be extensively infected with tuberculosis. Some of the results obtained in this country may be noticed.

**Tuberculin Testing in Wisconsin.**—The State of Wisconsin has used the tuberculin test more extensively and effectively than have any of the other States. Russell says that it is certain that two-thirds of the herds of the State are free from tuberculosis. Work was begun in 1893 with the testing of the college herd and has been pursued in the State at large ever since. It is estimated that at the present time the tuberculin test has been applied to from one-sixth to one-fifth of the milch cows. Hastings says it is certain that not over 5 per cent. and possibly not over 4 per cent. of the dairy cattle are tubercular but he also says that while the percentage of tuberculous cattle has decreased the number of infected herds has undoubtedly increased and that the great problem in Wisconsin is to prevent the introduction of tuberculous animals into herds now free from the disease. The extent to which the tuberculin test has been applied may be seen in Table 19.

TABLE 19.—TUBERCULIN TESTING IN WISCONSIN, 1893–1912 (HASTINGS)

| Year | Animals tested | Animals reacting | Percentage reacting |
|---|---|---|---|
| 1893–01 | 5,267 | 466 | 8.8 |
| 1901–02 | 425 | 84 | 19.0 |
| 1902–03 | 1,113 | 284 | 25.5 |
| 1903–04 | 914 | 171 | 18.7 |
| 1904–05 | 2,004 | 375 | 18.7 |
| 1905–06 | 1,655(*a*) | 253 | 15.3 |
| 1906–07 | 9,718 | 1,726 | 17.7 |
| 1907–08 | 15,816 | 1,291 | 8.1 |
| 1908–09 | 40,993 | 2,334 | 5.7 |
| 1909–10 | 48,181(*b*) | 2,171 | 4.3 |
| 1910–11 | 206,631 | 6,000(*c*) | 3.0 |
| 1911–12 | 32,272(*d*) | 1,367 | 4.2 |

(*a*) Slaughter demonstrations begun.
(*b*) Indirect compulsory legislation.
(*c*) Estimated.
(*d*) Indirect compulsory legislation repealed.

The Wisconsin methods are worthy of close study not only because they have been tried on a large scale but because of the policy of the State in not confining the testing with tuberculin to veterinarians but

in accepting tests made by cattle owners or by some one that has become acquainted with the test by observation and instruction. Recently, certificates of competency to make the test have been granted by the State Live Stock Sanitary Board to those passing its examinations and the tests made by such persons have been accepted when it was apparent they were carefully made, but evidence of untrustworthy work is penalized by revocation of the permit. The work done by professional and non-professional testers has been compared recently by Hastings who sets forth figures showing that there is little difference between them. It is contended that in granting the right to test in this way the welfare of veterinarians is not materially injured for tuberculin testing is so time-consuming that really competent men cannot afford to undertake it extensively and on the other hand this lifting of veterinary fees makes testing less burdensome to the farmers and State. Moreover, placing the opportunity to test in the hands of the farmer stimulates his interest in the tuberculosis problem, gives him confidence in the test and makes him less suspicious that mercenary motives are behind legislation encouraging its application. Finally, by making the test himself the farmer becomes familiar with the disease, a result which it is agreed must be attained before real progress can be made in controlling it.

In 1916 as a result of the efforts of the Commissioner of Agriculture, the State veterinarian and the Live Stock Sanitary Board of Wisconsin, the State has come forward with a plan for establishing "accredited herds" from which it is believed animals can be shipped to other States without undergoing the tuberculin test.

A policy of partially compensating the owner for his condemned stock has enabled him to rid his stock of the disease without suffering undue financial loss. The burden of expense to the State has been greatly lessened by slaughtering condemned animals and selling the carcasses that pass federal meat inspection.

The results in Wisconsin of inspection of carcasses by the federal meat inspection service is appended in Table 20.

TABLE 20.—THE RESULTS OF INSPECTIONS BY THE B. A. I. OF THE CARCASSES OF ANIMALS THAT REACTED TO TUBERCULIN TESTS IN WISCONSIN (HASTINGS)

| | 1906–07 | 1907–08 | 1908–09 | 1909–10 | 1910–11 | 1911–12 |
|---|---|---|---|---|---|---|
| Reacting animals | 1,726 | 1,291 | 2,334 | 2,171 | 6,000[1] | 1,367 |
| Animals killed | 1,118 | 1,106 | 1,816 | 1,814 | 5,034 | 1,056 |
| Animals passed as fit for food | 574 | 717 | 1,052 | ..... | 3,866 | 751 |
| Animals condemned | 544 | 389 | 764 | ..... | 1,168 | 305 |
| Percentage of animals condemned | 48.0 | 35.0 | 42.0 | ..... | 23.2 | 28.7 |

[1] Estimated.

**Tuberculin Testing in Hawaii.**—In Hawaii, in May, 1910, the testing of the dairies that supply Honolulu was begun and since, every dairy on the island of Oahu, producing milk commercially and those rearing cattle for sale have been tested by the intradermal method. Few cases of tuberculosis were found in range cattle. Comparison of the results in Table 21 shows that at every test there were more reactors in the city than in the country dairies.

Table 21.—Tuberculin Tests in the Territory of Hawaii, 1910–11–12

Honolulu City Dairies

| Test | Number of dairies | One or more reactors | Per cent. of clean dairies | Animals tested | Animals condemned | Per cent. of animals diseased |
|---|---|---|---|---|---|---|
| 1 | 51 | 35 | 31.4 | 1,404 | 439 | 31.26 |
| 2 | 78 | 21 | 73.1 | 1,778 | 160 | 8.90 |
| 3 | 77 | 17 | 77.9 | 2,056 | 111 | 5.39 |

Island of Oahu

| Test | Number of dairies | Number of animals tested | Number of animals condemned | Number of suspicious reactors | Number of animals passed | Per cent. of animals condemned |
|---|---|---|---|---|---|---|
| 1 | 70 | 1,955 | 469 | 52 | 1,434 | 23.98 |
| 2 | 137 | 4,162 | 226 | 12 | 3,924 | 5.80 |
| 3 | 107 | 5,361 | 204 | .. | 5,157 | 3.80 |
| Total. | ..... | 11,478 | 899 | 64 | 7,515 | 7.80 |

**Tuberculin Testing in North Carolina.**—In North Carolina, testing from 1909 to 1911 showed that the native cows are remarkably free from the disease; in 1909 no reactors were found among them and the 3 years' work indicates that only about 0.1 per cent. of these cows were tubercular. In Table 22 the high number of reactors in 1910 occurred chiefly in imported cattle and in herds wherein infected cattle had been allowed to stay.

Table 22.—Tuberculin Tests in North Carolina, 1909–1911 (Chrisman)

| Date | Number of cattle tested | Number of reactors | Number of suspects | Percentage of reactors |
|---|---|---|---|---|
| 1909 | 990 | 35 | .. | 3.53 |
| 1910 | 1,997 | 136 | 32 | 6.81 |
| 1911 | 3,484 | 49 | 8 | 1.40 |
| Total........ | 6,471 | 220 | 40 | 3.40 |

These results are very interesting for North Carolina is a State with

no big cities; in fact, at the time these tests were made the largest contained less than 35,000 inhabitants so that in no region is production forced. Consequently there has not been the effort to develop large producing cows of pronounced dairy type so that there has been little importation of cattle from outside the State; the native cow has sufficed. Cows are kept out-of-doors most of the year. So, bringing in the disease has not been common and the cows have had a minimum of exposure in infected barns. When the time comes that extensive importation of high-bred stock becomes common there is danger, unless great care is exercised, that tuberculosis may come with it, which emphasizes the responsibility breeders have in this matter and which should spur them on to acquire tuberculosis-free herds.

**Tuberculin Testing at Savanah, Ga.**—In 1914–15 Dr. D. C. Gillies, for the Board of Sanitary Commissioners of Savannah, Georgia, applied the tuberçulin test to the forty-seven herds supplying the city with milk. Dairymen had practiced cross breeding freely so that the resulting type of cattle, though superior to the native Piney Woods stock, is inferior to that stock improved by the use of purebred bulls. The majority of the herds were composed of grade Jerseys, Guernseys and Holsteins with a few native scrubs. It was found that seventeen, or 36 per cent., of the herds were absolutely free from tuberculosis, eleven, or 23 per cent., contained suspicious reactors and nineteen, or 40 per cent., contained positive reactors. In all, 1,523 animals were tested, of which 1,347, or 88.36 per cent. were non-reactors, seventy-nine, or 5.28 per cent., suspicious reactors, and ninety-seven, or 6.36 per cent., positive reactors. Three herds furnished forty-five suspicious reactors (57 per cent. of all of them) and sixty-six positive reactors (68 per cent. of all of them). Dr. Gillies believes that tuberculosis was introduced years ago, and has spread very slowly ever since. He found the native cattle almost without exception free from tuberculosis and that the disease was not more prevalent in one than in any of the other dairy breeds. The serious feature brought out by the test is that 64 per cent. of the herds contained either suspicious or positive reactors.

**Tuberculin Testing in Chester County, Pennsylvania.**—In Chester County, Pennsylvania, the Supplee Dairy Co. conducted an anti-tuberculosis campaign under the direction of Lane with the results that appear in Table 23.

TABLE 23.—TUBERCULIN TESTS IN CHESTER COUNTY, PENNSYLVANIA (LANE)

| Date | Herds tested | Herds diseased | Per cent. of herds diseased | Cows tested | Reactors | Per cent. of reactors |
|---|---|---|---|---|---|---|
| 1909 | 86 | 41 | 47.6 | 1,063 | 197 | 18.10 |
| 1910 | 51 | 11 | 21.5 | 585 | 27 | 4.61 |
| 1911 | 29 | 4 | 13.7 | 373 | 7 | 1.87 |

**Tuberculin Testing in Minnesota.**—Some Minnesota figures are given by Gillie. In the year ending Aug. 1, 1908, 25,887 grade cattle were tested with 7.7 per cent. reactors and in the same period 1,329 purebreds were tested with 36.8 per cent. reactors. The law requiring the test of purebred cattle sold for breeding purposes went into effect Jan. 1, 1910. In the first 7 months 3,035 such cattle were tested with 11.2 per cent. reactors and from Aug. 1, 1910, to Aug. 1, 1911, 1,717 tests were made under the law and of these 1,214 were of cattle tested the year before; only 0.9 per cent. of reactors were found out of the whole number. In Table 24 are the results that he obtained when at the Minnesota Experiment Station.

TABLE 24.—TUBERCULIN TESTS AT MINNESOTA EXPERIMENT STATION (GILLIE)

| | Number cattle tested | Number of reactors | Per cent. tuberculous |
|---|---|---|---|
| Native | 2,839 | 223 | 7.8 |
| High grades | 157 | 17 | 10.8 |
| Purebreds | 258 | 41 | 16.6 |
| Barns with fair ventilation | 1,087 | 67 | 6.1 |
| Barns with poor ventilation | 1,210 | 201 | 16.6 |

**Tuberculin Testing in Montclair N. J.**—In 1907 when Montclair, N. J., required that either the tuberculin test be applied to the herds supplying the town or that the milk be pasteurized, 17 herds in New Jersey were tested with the results that appear in Table 25.

TABLE 25.—TUBERCULIN TEST OF HERDS SUPPLYING MONTCLAIR, N. J. (WELLS)

| Herd | Number of cows | Per cent. of reactors | Cubic feet of air space per cow | Square feet of window area per 500 cu. ft. of air space |
|---|---|---|---|---|
| 1 | 93 | 29.0 | 780 | 2.7 |
| 2 | 69 | 18.0 | 860 | 2.2 |
| 3 | 41 | .... | 1,000 | 1.5 |
| 4 | 35 | .... | 455 | 3.1 |
| 5 | 35 | 2.9 | 685 | 2.8 |
| 6 | 28 | 53.6 | 640 | 1.9 |
| 7 | 27 | 48.1 | 410 | 4.0 |
| 8 | 27 | 14.8 | 490 | 4.1 |
| 9 | 23 | 34.8 | 1,400 | 3.1 |
| 10 | 14 | 50.0 | 710 | 3.0 |
| 11 | 13 | 7.7 | 475 | 2.0 |
| 12 | 11 | 27.3 | 370 | 2.8 |
| 13 | 10 | .... | 420 | 3.0 |
| 14 | 9 | 44.4 | 460 | 2.2 |
| 15 | 6 | 83.3 | 390 | 3.7 |
| 16 | 4 | 25.0 | 390 | 3.7 |
| 17 | 3 | 33.3 | Part of barn used as cow stable | |

These figures as regards ventilation in Tables 24 and 25 are worthy of remark. The higher percentage of reactors in the barns with poor ventilation as noted in the Minnesota results, are such as may be expected but the Montclair figures show that often stables with ample air space and window area house badly infected herds. Good ventilation and lighting are helpful in keeping down tuberculosis but a cow with open lesions, after all, is the great big factor in spreading the disease.

**The Lesson of Tuberculin Testing.**—Such is the evidence given by tuberculin testing; it shows that bovine tuberculosis has a firm hold wherever dairying has become an important industry. In some places the disease has been but recently introduced; many herds in the United States are free from it. The problem is to keep them so and to eradicate the plague from herds that are already affected. The task is stupendous but it must be performed because infected milk and dairy products menace the young and because the disease cuts deeply into the profits of the producer and greatly increases the cost of living to the consumer. The emphasis that has been laid on the public health aspect of the problem has probably tended to make breeders and dairymen feel that the principal way in which they were concerned was in preventing measures, designed to debar the marketing of infected dairy produce, from being drastic. On the other hand, the consumer has no doubt often felt that he was being imposed on in being compelled to pay the farmer for slaughtered diseased stock even though it was condemned by the representative of the consumer and in his interest. Both viewpoints are wrong and those who are endeavoring to improve the situation must lose no opportunity to drive home the fact that both producers and consumers are supporting an industry that is oppressively and outrageously taxed by the ravages of a communicable disease. The tax will be levied whether efforts to control the disease are made or not. By letting the disease run, the inconvenience of paying to uproot it, is avoided but collection is made in the end, in the form of feeding animals that are too sick to yield milk in paying quantity, of lessened fecundity of the herds, of loss of valuable stock, of suspicion that is engendered of purebred stock, of loss of meat that is condemned as food and of bills that are paid the physician and surgeon for care of tubercular patients, and the undertaker for burying them. The welfare of all demands that the disease be attacked, not in a desultory fashion but in a carefully thought out campaign, planned to be fought out on the lines laid down for 10 years or more if necessary. As yet no fully satisfactory plan for dealing with the menace has been evolved anywhere. The methods that are actually in use may be profitably considered.

**Control of Tuberculosis by Immunization.**—In the first place, it should be noted that attempts have been made to immunize dairy animals but

as yet these efforts have not developed beyond the stage where they are of more than scientific interest.

**Control by Tuberculin Testing.**—The plan that is probably most familiar to Americans is that of testing animals with tuberculin and destroying the reactors. If retests are made, there is little doubt that herds would be enventually cleaned up but the system is too expensive to be generally adopted. To apply it to a whole State would require an army of testers and the value of property destroyed would be so great as to be prohibitive. Moreover, a severe shortage of milk would very likely result so that this method can be applied only in a limited way. Had it been adopted before tuberculosis had obtained a firm hold of American stock, it no doubt would have achieved success, but now it is too harsh.

**The Manchester Method of Control.**—In England, the Manchester system is in use; it is based on the unsound hypothesis that tubercle bacteria get into milk only through udder lesions or at least principally that way. The law on which the system is based authorizes the proper officials to collect milk samples and to visit dairies both within and without the city proper. The milk of all dealers is submitted at regular intervals to microscopical examination and is also tested by injection into guinea-pigs. In case the mixed milk proves to be infected with tuberculosis germs the herds are visited and the animals examined physically by a veterinarian. Animals with tuberculosis of the udder are removed from the herd but the law does not provide for their destruction. Milk from the animals removed must not be sold for human consumption nor can the cow be kept with other cows in milk. There is nothing to prevent their being kept with dry stock nor with calves and disinfection after removal of the diseased animals is not required. It is easy to see that the law is a compromise and was enacted in the belief that it would reduce the amount of tuberculous milk on sale. It has been held, that by removing the cows with udder lesions, the law would lessen the amount of open tuberculosis in the herds and gradually effect their betterment. The actual result has been that in the first few years after enactment bad conditions were improved but so far as the milk is concerned it has been found that after 10 years in Manchester the tuberculous samples dropped down to 6 per cent. and in Sheffield to 9 per cent. and stayed there. Statistics show that in neither city during the same period had there been any percentage reduction of udder tuberculosis.

**The Ostertag Method of Control.**—The Ostertag method is based on the theory that it is the open cases of tuberculosis that spread the disease and that all but a few of these are detectable by *frequent* and *thorough* physical examinations of the herds. As tuberculin does not distinguish open from closed cases it is not used. The herd is examined by a veterinary inspector after which there is a bacteriological examination of the milk. If tuberculosis is found in the milk or if animals whose

appearance arouses suspicion of the disease are discovered, reëxamination of the animals is made. Those exhibiting clinical symptoms are isolated or slaughtered. Calves are removed promptly after birth and kept separate some months when they are placed with other cattle. During the period of separation the calves are fed on the milk of sound animals or on the pasteurized milk of infected ones. The method is undoubtedly helpful but is objected to in the United States because it amounts to treating the whole herd as though it were tuberculous and because of the expense attached to the frequent veterinary examinations which are the vital part of the scheme of treatment. Many regard the method as palliative rather than curative.

**The Bang Method of Control.**—The Bang system is more thorough than those that have been described. The entire herd is treated with tuberculin, the reactors are separated from the sound cattle and the premises disinfected. Doubtful cases are kept under observation and if not separated from the healthy animals in the first place are so whenever there is reason to believe them diseased.

The tubercular animals are preferably kept in a separate building on a part of the farm away from the sound stock but where necessity compels, they may be kept in a part of the barn containing the others, if they are walled off so completely that there is no possible communication between the two. The sick and the well animals are pastured separately. Owing to the ease with which manure and other infectious material may be transferred from one herd to another separate attendants for the two parts of the herd should be provided if it can be afforded. The reacting and non-reacting cattle should not have the same watering troughs.

Cows that have tuberculosis of the udder are slaughtered. Calves that are dropped by tubercular mothers are taken away before they have a chance to suck and are raised on the milk of sound cows or on milk of the tubercular stock pasteurized at 176°F. Experience has taught that calves are, with but rare exceptions, born free from tuberculosis. The rearing of calves from advanced cases is not encouraged for the few cases of intra-uterine infection that do occur most often arise in the progeny of such cows. The whole stock including the calves is retested every half year, reactors removed and necessary disinfection attended to. Ultimately a sound herd is built up, and the diseased stock out of which it came is slaughtered.

The advantages of the system are: (1) It is efficient, for by its use a tuberculosis-free herd can be obtained in from 1 to 3 years though sometimes 6 to 8 years are required in a badly infected herd. (2) The initial expense is not great. (3) It does not disturb trade. (4) Owners and herdsmen obtain thorough knowledge of the disease, an acquisition of inestimable value to them. The disadvantages are: (1) Extra labor is required. (2) Great vigilance is exacted for any laxity will undo the work

of years. (3) Perseverance is demanded of the owner, for final success can be won by only persistent effort in the face of discouraging setbacks.

In Denmark where the Bang system was developed there have been formed by the farmers associations which enable the members to bring their tubercular stock into a single herd and therefrom raise up sound animals at a minimum of trouble and expense. The formation of similar societies has been proposed in the United States but actually, none seem to have been created. In some States there has been some discussion of the suggestion that the State assist the farmers in the formation and care of such herds, with the object of encouraging dairymen to establish herds of tuberculosis-free animals and of conserving breeding animals of valuable dairy strains that are now butchered after reacting to tuberculin. The proposition has some merit and no doubt in competent hands would prove satisfactory but if conducted as a political sinecure it would do a deal of harm.

**The Birmingham Method of Control.**—Savage has described a mode of maintaining the Bang system in Birmingham, England, that might be used in small cities in the United States. The city supplies farmers the tuberculin and veterinary assistance necessary for testing their cows twice a year. The farmer disinfects the stables and separates the diseased and healthy animals. Tuberculosis-free cows are marked and those having tuberculous udders are sold for slaughter. The city gives quarterly certificates to owners of tuberculosis-free herds and keeps a public list of their farms. In this way several sound herds have been built up and more are on the way.

**Use of the Bang Method in the United States.**—In the United States and Canada private owners have built up tuberculosis-free herds and so have several of the experiment stations, by the Bang method. The Wisconsin Stations, the first to use it, began in 1896 with 16 reactors and 18 well cows. In February, 1899, the herd had 27 well animals bred from reactors. The New York Station in 1901 had 13 healthy animals and 17 tuberculous. It lost four healthy animals by fire and only a few heifer calves were born but in 1905 it had a herd of 30 sound and six tubercular animals. The latter were slaughtered. The experience in building up the herd at the Illinois Station has been told by Hayden. In Table 26 appears a statement of the females in the herd, the number tested and the number of reactors.

There were several reasons for not testing the entire herd at different times but usually the principal one was that many of the animals were regarded as too young to test.

Despite great loss, and with the addition of a few calves from another herd, the number of females increased from 55 in 1907 to 91 clean females in 1912. In the period 19 females were purchased and 32 non-reactors sold. The herd was well-seeded with tuberculosis previous to 1908 and

the harvest was reaped in May of that year when 32.6 per cent. of the cows reacted. Of 47 mature cows in 1906 only three remained in the herd after 1909 and only five of those that went out did so for other causes than tuberculosis which shows that when a herd of mature animals becomes badly diseased it is probably best to consider the entire herd affected and to treat it accordingly. In the breeding herd 170 different females were tested and 50 or about 30 per cent. reacted.

Table 26.—Tuberculin Testing at Illinois Experiment Station, 1906–1912 (Hayden)

| Year | Season | Number of females in herd | Number tested | Number of reactors |
|---|---|---|---|---|
| 1906 | May | 44 | 34 | 13 |
| | December | . . | 15 | 10(*a*) |
| 1907 | June | 55 | 5 | 2 |
| 1908 | June | 67 | 50 | 26 |
| | Fall | 56(*b*) | 36 | 3 |
| 1909 | Fall | 78 | 67 | 4 |
| 1910 | Spring | 72 | 57 | 1 |
| | Fall | 77 | 72 | 0 |
| 1911 | Spring | 88 | 70 | 1 |
| | Fall | 96 | 90 | 1 |
| 1912 | March | 95 | 81 | 4 |

(*a*) Five of the reactors had reacted previously.

(*b*) Seven animals acquired by purchase.

From May, 1906 to December, 1911, five mature bulls and 32 young ones ranging from 6 months to 2 years of age were tested; three reacted, of these, one that reacted was fed on sterilized milk like the other calves but still developed the disease either because this milk was not always properly heated or for some other reason. Besides these, 26 bull calves under 6 months of age from sound cows were sold.

In Table 27 are shown the results obtained from 19 of the purebred cows that were quarantined in 1908 and from four others that were quarantined later.

The quarantined herd was kept in existence for about 2 years at a cost of $60 a head a year, or a total cost of $2,700 for the 2 years. During that time the gross returns were approximately $4,436 making a net return of $1,736. The cost was probably greater than it would be for an ordinary herd.

**The Disinfection of Stables.**—The disinfection of the stable is a matter which must be carefully attended to on the removal from the herd of animals suffering from tuberculosis or other infectious diseases. The first step is to clean up thoroughly, being careful to scrape the manure from the floor and walls and to sweep the stable clean so that the germi-

TABLE 27.—TUBERCULIN TESTING OF 23 COWS AT THE UNIVERSITY OF ILLINOIS EXPERIMENT STATION, 1908–1910 (HAYDEN)

| Herd number | 1908 | 1909 | 1910 | Post-mortem | Value before tubercular | Received for carcasses | Received for milk | Value of progeny | Total |
|---|---|---|---|---|---|---|---|---|---|
| 10 | T + | T + | ........ | + Cond. | $100 | $ 6.75 | $ 84.71 | ...... | $ 91.46 |
| 16 | T + | T + | T + | + | 200 | 43.67 | 163.71 | $100 | 307.38 |
| 33 | T + | .... | T + | − | 100 | 67.10 | 107.96 | 75 | 250.06 |
| 36 | T + | .... | T + | + | 150 | ........ | 137.13 | 200 | 337.13 |
| 39 | T + | .... | T + | + | 100 | 27.77 | 113.44 | 80 | 221.21 |
| 49 | T + | .... | T + | + | 200 | ........ | 98.77 | 100 | 198.77 |
| 51 | T + T + | .... | T + | + Cond. | 100 | 7.58 | 127.88 | 85 | 220.46 |
| 52 | T + | T + | ........ | + Cond. | 75 | 5.00 | 98.25 | ...... | 103.25 |
| 54 | T + | T + | ........ | + | 100 | 25.50 | 62.74 | ...... | 88.24 |
| 56 | T + | .... | T + | + | 150 | ........ | 78.61 | 5 | 83.61 |
| 57 | T + | T + | + | + Cond. | 75 | 6.75 | 76.41 | ...... | 83.16 |
| 58 | T + T + | T + | ........ | + Cond. | 100 | 7.00 | 77.87 | 75 | 159.87 |
| 59 | T + T + | .... | T + | + | 100 | 57.91 | 111.38 | 70 | 239.29 |
| 60 | T + | .... | T + | + | 125 | 44.59 | 127.14 | 90 | 261.73 |
| 64 | T + | .... | T + | + | 150 | 30.40 | 130.08 | 180 | 340.48 |
| 66 | T + | .... | T + | + Cond. | 150 | 7.96 | 111.15 | 100 | 219.11 |
| 67 | T + | .... | T + | ? | 150 | 33.12 | 115.74 | 150 | 298.86 |
| 71 | T + | .... | T + | + | 150 | 34.43 | 139.63 | 180 | 354.06 |
| 72 | T + | .... | T + | + | 150 | 43.67 | 25.91 | 80 | 149.58 |
| 41 | ........ | .... | T + | + | 175 | 43.61 | 128.99 | 100 | 272.60 |
| 29 | ........ | .... | T + ? | ? | 175 | 25.50 | 57.05 | ...... | 82.55 |
| 42 | ........ | .... | T + T − | + | 175 | 12.50 | 23.75 | ...... | 36.25 |
| Heifers | ........ | .... | T + T − | − | 100 | 37.56 | ...... | ...... | ....... |
| | | | | | 3,050 | 568.37 | 2,198.30 | 1,670 | 4,436.67 |

T + Means reaction.
T − Means no reaction.
Cond. Means condemned.

cide can easily come into contact with the surfaces to be disinfected. It is very difficult to disinfect worn and decayed woodwork; so rotten floors and mangers should be torn out and burned. The earth from dirt floors should be removed to a depth of at least 4 in. so as to get rid of the fecal discharges it has absorbed. The next step is to apply the germicide. There are many disinfectants from which to choose and in making a selection several points should be borne in mind, namely: (1) their efficiency, (2) their non-poisonous qualities, (3) their freedom from irritating action on man and beast and from odors that will cling to the building and be absorbed by the milk making it unsaleable, and (4) their cost. As a rule proprietary disinfectants should be avoided because if they have any value at all it depends on some of the well-known germicides that costs less under its own name than when masquerading under a fancy title bestowed by some manufacturer. The common disinfectants are mercuric chloride or corrosive sublimate, formalin, chloride of lime or bleaching powder, carbolic acid or phenol, cresol, compound solution of cresol or liquor cresolis compositus, crude carbolic acid and sulphur.

**Tuberculosis in Swine.**—The swine in most cases contract the disease

from eating cattle droppings for the grain they contain, or from being fed on skim-milk from tuberculous cows. They may also become infected with tuberculosis germs of the avian type from the droppings of fowls. In the latter case the disease is usually of a local character while the bovine bacilli give rise to a generalized infection. Wherever slaughter houses keep record of the points from which the animals come and as to whether they are tuberculous or not, there is afforded evidence that may be utilized in tracing up diseased herds and in mapping regions that are so generally infected that the animals coming therefrom may be expected to be tuberculous. In this connection it should be said that range animals are commonly pretty free from the disease, but of late years a tendency for it to increase in this sort of stock has been noted. Thus reports of meat inspectors in San Francisco and Los Angeles indicate that the proportion of cattle from certain ranges which are affected with tuberculosis has increased from 1 to 5 per cent. in the last five years.

**Viability of B. Tuberculosis in Butter and Ice Cream.**—Dairy products are to some extent infected with the germs of bovine tuberculosis. Cream, whether raised by gravity or separated, carries bacteria with it so that it is natural for both butter and ice cream made from the milk of tubercular cows to contain tubercle bacilli since neither the salting of the butter nor the freezing destroy the microbes.

Briscoe and MacNeal have compiled a list of 39 investigations of the butter of 24 European and one American city; out of 1,233 samples 163 or 13.2 per cent. were infected with the germs of tuberculosis. They found that two out of six samples of butter from Urbana, Ill., examined, carried the bacilli. By experiment they found that tuberculosis germs survive in a virile condition for a much longer period than the butter is usually held in cold storage. This is in line with Mohler's statement that tubercle bacilli retain their virulence in butter made in the usual way and stored under ordinary market conditions until time of sale. It should be mentioned that butter made from carefully pasteurized cream does not carry tuberculosis germs.

**Viability of B. Tuberculosis in Oleomargarine.**—In the usual way of making oleomargarine in the United States the fat used is comminuted at not over 122°F. for 1½ hr. Then sour milk is added and the whole mass thoroughly mixed; dairy butter is next added and a certain proportion of vegetable oils. Next, enough more oils are added to lower the temperature to that of dairy butter. Therefore, opportunity is afforded the product to be infected in three ways, viz.: (1) by the fat from the cattle, for tubercle bacilli will withstand a temperature of 122°F. for some hours; (2) from the butter and sour milk that is added; and (3) in the process of manufacture it may be contaminated by tuberculosis germs of human origin. Briscoe and MacNeal enumerate seven investigations of oleomar-

garine in six European cities and in nine of the samples from two different cities tubercle bacilli were found.

**Viability of B. Tuberculosis in Cheese.**—Whether or not cheese contains tubercle bacilli depends on the time that elapses in the ripening process. In Switzerland it was demonstrated that in Emmenthal cheese the tubercle bacilli died between the thirty-third and fortieth day of ripening and as the process is continued considerably longer before the cheese is marketed there is little cause to be apprehensive that the bacilli survive. The bacilli of tuberculosis live much longer in cheese made by the cheddar process. In Switzerland it was found that during ripening they lived 104, but not 111 days. In Maryland, Mohler and Doane, in this variety of cheese, demonstrated tuberculosis germs after 122 days, a period that approaches the limit of that it is sometimes allowed to ripen. Altogether it seems unlikely that cheese often carries the germs of tuberculosis. Of course cottage cheese and any other that is eaten soon after it is made is likely to be infected with the bacilli if it comes from the milk of tubercular cows.

**Need of a Comprehensive Tuberculosis Policy.**—It is apparent that the problem of bovine tuberculosis is very urgent.

**Foot-and-mouth Disease.**—This highly contagious disease chiefly affects ruminants and swine. It gets its name from the fact that it is characterized by vesicular eruptions on the mucous membrane of the mouth and on the skin between the toes of the affected animal. The causative organism has never been isolated but it is held to be a filterable virus. Aphthous fever, as the malady is sometimes called, is common in Europe but has never gained permanent foothold in this country because whenever it has appeared, the affected herds have been promptly destroyed by slaughter. The disease is communicable to man, children being more susceptible to it than adults. It is spread by contact, through the vesicles, nasal discharges, saliva, feces and milk. Most often it is acquired from ingesting infected milk or its products, but it may be also, through abrasions in the skin, in handling or slaughtering the sick animals. The incubation period is generally 3 or 4 days and the progress of the disease has been described as causing fever, vomiting, sometimes painful swallowing, heat and dryness of the mouth, followed by an eruption of vesicles on the mucous membrane of the mouth and rarely on the fingers. The vesicles are about the size of a pea, soon rupture and heal slowly. Patients usually recover; the few deaths are mostly among children. The disease is uncommon in the United States but a few cases were reported in humans in the epizootics of 1870, 1902, 1908 and 1914.

**Anthrax.**—This disease is caused by *Bact. anthracis.* Man is rarely infected through the alimentary tract but is sometimes. That he might be, seems to have been known for a long time for in 1599 during an anthrax epidemic in Venice the sale of meats, milk, butter and fresh cheese was

prohibited under penalty of death. The bacterium has been recovered from the milk of cows suffering from the disease but there seems to be only very slight danger of men taking the disease from milk, for the flow is suppressed or if delivered is altered in character and also the cow dies a few hours after the beginning of the attack. Ernst states that the dangers of infection through the ingestion of raw milk containing the bacteria is slight because anthrax bacteria are digested by the gastric juice but that it does not destroy the spores. Consequently infection of the milk by spores from the manure of diseased animals or of healthy ones that have eaten food containing anthrax spores, and also by spores derived from dust and straw offers possibilities of dangers. That infections from milk do occur is known. Kober cites the case of the daughter of a plantation owner at Barbados in 1795, who one morning drank most of the milk of a cow suffering from anthrax and who 4 days later showed symptoms of the disease which were followed by the development of a carbuncle on her right arm. Ernst instances the case of a typhoid fever patient who after drinking 1.5 liters of milk from a cow with malignant pustule of the udder, became infected with intestinal anthrax.

In a dairy district supplying Chicago, from June to August, 1910, an outbreak of anthrax occurred, which threatened the milk supply of the city. The epidemic lasted about 60 days. Twenty farms were involved and 500 cows exposed of which number 87 died of the disease. The outbreak spread rapidly and required vigorous efforts to check it. Inspectors from Chicago were put in the district and quarantined every farm on which the disease was actually present or was suspected of harboring it. All milk on these farms was destroyed. This vigorous campaign kept the milk out of Chicago. In the course of the epidemic one farmer died of anthrax but apparently did not contract the disease from milk.

**Cowpox.**—This disease is believed to be smallpox modified by passage through the cow. It is well known that milkers and others, who are brought into close contact with cows having the disease, break out with it. Indeed, it was observation of this fact and that milkers who had contracted it seldom had smallpox that led Jenner to propose vaccination. It is within the bounds of possibility that infants and others might get cowpox from drinking milk containing pustular matter abraded from the udder in milking but it is not known that any ever did. However, boards of health properly exclude from the market, the milk of cows suffering with cowpox.

**Rabies.**—That anyone should milk a rabid animal is most improbable but as it has been reported that the disease has been transmitted to the young in the milk, calves of diseased animals should be prevented from sucking.

Ernst cites a case reported by Bardach of a nursing infant remaining

well, although it fed on the milk of a woman suffering from rabies until one day before her death.

**Milk-sickness.**—In pioneer days, in restricted areas in the Central West, this disease worked such havoc to stock and man that it was regarded as a serious menace and rewards were offered by legislatures, for the discovery of its cause. It appeared about 1800 and continued of importance till 1860 when it all but vanished. The sickness has never been known east of the Alleghenies nor outside of the United States. Cultivation of the soil favors the disappearance of the disease. The observation was early made that man might be made sick from using the milk, butter or meat of animals having the disease known as the trembles or slows and that probably the ailment of man was identical with that of the animals.

In cattle the first indication of the sickness is dullness, followed by violent trembling and great weakness which increases during the succeeding day until the animal becomes paralyzed and usually dies though old reports indicate that some of the animals recovered but were greatly impaired by the disease. In man the disease develops marked weariness, retching and insatiable thirst. Respiration is labored, peristalsis ceases, the temperature becomes subnormal and the patient apathetic. Paralysis gradually ensues and death takes place quietly without rigor mortis.

The early settlers had no idea of the cause of the sickness in animals, but found that they contracted it, if allowed to feed in certain localities. So they expected to find that some plant or mineral poisoned the stock. Early students of the illness made lists of plants and minerals of the areas that were known to be dangerous. Jordan and Harris solved the mystery in 1907 when the appearance of the disease in New Mexico gave them an opportunity to apply bacteriological methods in studying it. They isolated a bacillus from the intestinal contents of affected animals and man, that was sometimes found in pure culture in the internal organs of fatal cases and that, fed to dogs and calves, reproduced in part, at least, typical symptoms of the slows. They call the organism *B. lactimorbi*.

**Malta Fever.**—Malta fever is caused by the *Micrococcus melitensis* which was discovered by Bruce in 1887, but knowledge as to the mode of transmission of the disease was worked out from 1905 to 1907 by the British Commission for the investigation of Mediterranean fever. The disease is prevalent in the Mediterranean Basin and in the United States, in the goat-raising States to which it has been imported in blooded animals from Europe and Asia Minor. As yet, it seems to have been found only in Texas, Arizona, and New Mexico, but it may reasonably be suspected that careful diagnostical work will demonstrate the disease in California and Oregon. The British investigations were undertaken because of the prevalence of Malta fever in the island of Malta. It was found that the specific micrococcus is contained in the milk und urine of apparently healthy goats so that there is ample opportunity for man to infect himself

by drinking goat's milk and less readily by inhaling infected dust and by eating food that has been exposed to such dust. In this connection it should be noted that while the micrococci succumb readily to heat and disinfectants they manifest considerable resistance to drying. In certain parts of Texas the indications are that dust transmission of the disease is important. Possibly the disease may be spread by flies.

Malta fever is characterized by profuse perspiration, constipation, frequent relapses often accompanied by rheumatic or neuralgic pains and sometimes by swellings of the joints. The disease is long drawn out and has a mortality rate of about 3 per cent. In Texas it has been known as Rio Grande or goat fever and is sometimes confused with typhoid fever though practitioners often recognize that the disease is not true typhoid. Isolation of the micrococcus and agglutination tests serve to distinguish the diseases. In the United States, it is apparently in the kidding season that the disease is most often contracted, for the reason that it is at this time that the milk flow is heaviest and that at this time, also, the rancher's whole family live with the goats. Precaution should be taken to boil the milk and to locate the pens so that there is a minimum of dust exposure to the family.

**Contagious Abortion.**—The bacillus of contagious abortion is common in market milk and the fact that it was pathogenic for cattle roused the suspicion that it might in some way be for man. Shroeder at one time believed that *Bact. abortus* might be responsible for tonsillar troubles and adenoids in children but neither he and Colton nor Mohler and Traum were able to prove the theory by testing a large number of diseased tonsils and many samples of adenoid tissue excised from children.

Larson and Sedgwick in 1913 called attention to the fact that the blood serum of children using milk from cattle infected with contagious abortion, often contains antibodies against *Bact. abortus.* In a series of 425 children whose blood was tested to either or both agglutination and complement fixation 73, or 17 per cent. gave a positive reaction. Certain groups of these children gave a much higher percentage of positive reactions; thus the children of one institution gave over 40 per cent. and of another as high as 48 per cent. Children that were fed on the milk of herds known to be free from the disease did not give the reaction while those fed on ordinary market milk did. The authors state that while it could not be determined whether the presence of these antibodies in the blood of children is the result of an infection or of antibody absorption through the digestive tract they incline to the former interpretation because they consider it improbable that antibodies could be excreted in quantities sufficient to give a positive complement fixation test.

Cooledge found by experiment that *Bact. abortus* antibodies may be present in milk in great concentration and that they may be made to appear in the blood serum of adults by feeding them milk naturally

infected with *Bact. abortus*. He believes that antibodies appearing in this way indicate passive immunity due to the absorption in the larger intestine of antibodies from the infected milk and that there is no proof that *Bact. abortus* is pathogenic to man.

**Sore Teats.**—Udder-borne infections have been imputed to teat sores and Savage notes two instances in which diphtheria germs have been isolated from the ulcerated teats of cows belonging to herds supplying dairies that were implicated in outbreaks of the disease. It was not believed that diphtheria germs caused the sores but that the diphtheria was an added infection for which the milkers were responsible. Whether organisms that cause these sores are ever dangerous is not known; they may be so, but at present they are regarded lightly.

**Gastro-enteritis Caused by Udder Infection.**—Holst in 1894, reported four different outbreaks of gastro-enteritis in Christiania, Norway, that were traced to the consumption of the milk of cows affected with streptococcic mastitis. Lameris also, concluded that diarrhea may be caused by the use of milk of cows suffering from streptococcial infection of the udder. Others also, have reported outbreaks caused in this way. Groning and Holst have instanced cases where the milk had been boiled before those who partook of it were made ill. So there is the question whether the boiling was not thorough enough to kill the organisms or whether the bacteria elaborated poisons that were not destroyed by the heat applied.

In the United States one of the most definite outbreaks of this sort occurred in Gibbsborough and Berlin, N. J., on Oct. 15, 1915, on the milk route of dealer A who was supplied by three dairymen each of whose milk he bottled separately. On the day in question A put out 82 qt. of milk in all, 13 qt. of D's, 11 of C's and 58 of B's. Sixty pint bottles which were all that A delivered that day, except a few of D's milk that certainly did not cause illness, were filled with B's milk as were 28 quart bottles. Only 13 other quart bottles were put out by A that day. The bulk of the milk was produced and bottled on the 14th. In the two towns there were 55 cases of gastro-enteritis, simulating ptomaine poisoning and giving one or more of the symptoms of vomiting, dizziness, headache, prostration, pains in the stomach and diarrhea. All of the victims used dealer A's milk and among them were some of his own family. Because in 23 of the families that were attacked, pint bottles of dairyman B's were used and because his milk was in all probability used in eight invaded homes that took milk in quart bottles suspicion was fastened on his dairy. Investigation disclosed that two of B's own children who used the milk were stricken with pains in the stomach and vomiting and that the herd had been tended by a hired man but that when the sickness broke B examined the herd and on finding a cow with a bruised udder and injured teat, discharged the man and discarded the milk of the cow. Veterinary examination indicated that the

cow was tuberculous and showed her to be suffering from an extensive and acute inflammation of one quarter of the udder and that the milk from this quarter was contaminated with pus and blood. Microscopical examination of the milk showed numerous polymorphonuclear leukocytes and many streptococci in fairly long chains of 16 to 10 elements. Attempts to isolate the streptococci failed. In the opinion of the veterinarian the cases of illness reported on the milk route of A were due to the infected milk of B's cow for the following reasons:

1. All the 55 cases of illness in 31 homes occurred on A's milk route.
2. In 23 of these 31 homes, those who become ill consumed milk from bottles known to have been filled with the product of B's dairy.
3. The distribution of 28 quart bottles filled with milk from B's dairy will account for illness in eight homes where the milk from quart bottles was consumed. Only 13 quart bottles filled with milk from other dairies were distributed on the date in question.
4. All cases of illness were of similar character and occurred on the same date.
5. No more cases of illness occurred after milk from the infected udder was discarded.
6. Cases of illness occurred in both the families of A, the distributor, and B, the dairyman.
7. No other common food supply to cause the illness in 31 homes was found.

Out of a total of 82 qt. of milk distributed by dealer A on the 15th, 74 pt. of milk and 41 qt. of milk were accounted for and it was found that 364 people ate at the tables where this milk was served, 323 of whom drank the milk or used it in coffee or on cereals. Of this number 268 remained well and 55 or 20.5 per cent. took sick.

The repeated acute attacks of gastro-enteritis that occurred among the residents at, and visitors to a farm in the Phillipine Islands over a period of 3 years were shown by Barber to be due to a toxin elaborated by a white staphylococcus that occurred in almost pure culture in the udder of a cow, that was apparently in good health at all times except for a single attack of garget that occurred after the cases of gastro-enteritis had begun. The fresh milk was harmless and the toxin was produced only after the milk had stood some hours at room temperature. Persons using the milk continuously apparently developed some tolerance to the toxin. Two children used the milk regularly but never had attacks. Adults had light attacks and in one or two instances developed cases of chronic intestinal trouble. Visitors to the farm and Filippino employees had the worst cases. On discontinuance of the milk of the infected cow all trouble ceased.

**Gastro-enteritis Caused by Fecal Contamination.**—Some diarrheal infections may be derived from perfectly healthy animals that are handled

in an uncleanly manner thus affording opportunity for the milk to receive heavy fecal contamination. The diarrhea of infants may be due to various causes; it may be incited from improper food without definite connection with bacteria but Kendall has pointed out that the acute summer diarrheas that show "prostration and fever associated with mucus, pus and sometimes even blood" in the movements may be caused by various bacteria. He found that on the Boston Floating Hospital, in "one year the dysentery bacillus was the dominant type met with; the second year streptococci were conspicuous; the third summer was noteworthy because of the great number of cases in which the gas bacillus was the predominant organism encountered; while in the fourth summer an entirely different organism, somewhat resembling *B. mucosus*, made its appearance." This bacterial diarrhea is believed to be in part derived from milk that shows high bacterial count, the tender gastro-intestinal membrane being overwhelmed by mere numbers of the germs. Also, it cannot be denied that there may be in the feces of healthy animals germs which if they get into the milk may attain considerable development therein and become noxious to consumers, particularly to babies. This is believed to be the case at times with yeast cells and *B. subtilis* and even with the common *B. coli*. The milk of scouring cows is thought by some to be more likely than that of well ones to give trouble in this way and in herds whose milk is used especially for infant feeding the milk of such cows is withheld. Another organism, *Bact. welchii* which is often called the gas bacillus and by English writers *B. enteritidis sporogenes* and which is also known by other names, was found by Klein in the stools of the victims of an outbreak of diarrhea and Andrewes studied three outbreaks of a mild type which occurred in St. Bartholemew's Hospital, London, England, in which this organism was present in the stools of the patients and in the milk which was incriminated as the cause of the outbreak. In one of these epidemics 146 persons were taken ill in one night. The pathogenic power of the organism is variable; certain strains according to Theobald Smith form toxins if they are grown in media containing minimal amounts of sugar. In the vast majority of cases *Bact. welchii* seems to be a saprophyte living upon the intestinal contents and not a true invading organism. This microbe is an anaerobe and is rather widely distributed in nature, occurring in dust, the excrement of man, cows and the higher animals; in many samples of market milk and in large numbers in sewage. It is not a normal inhabitant of the intestinal tracts of nurslings. Kendall and Smith examined for *Bact. welchii*, 293 stools, some of which were normal and some were not. In 271 the result was negative, showing that the organism is rare in the stools of infants and young children. Eight of the stools showed the germs present but not in quantity to warrant their being considered significant. This result was not unexpected for the discharges of older children on a mixed

diet and those of a few infants sometimes contain the organism. In 14 cases *Bact. welchii* was found in sufficient numbers to sanction the belief that it was the exciting cause of the diarrhea. That fecally contaminated milk offers a possible source of infection with this organism must be admitted.

Simonds says that there are some reasons for believing that *Bact. welchii* of human origin may be virulent and that of bovine not so.

**Unclean Milk at the U. S. Naval Academy.**—There is evidence that impure milk is the cause of indefinite intestinal disorders among adults and that the substitution of a pure supply for an impure one is attended with good results. The experience at the U. S. Naval Academy at Annapolis, Md., is a case in point. A few years ago Paymaster Samuel Bryan, U.S.N., who was charged with provisioning the Naval Academy at Annapolis, Md., requested the Bureau of Animal Industry to test for tuberculosis some of the herds from which milk was being obtained by contract. The demonstration of the disease and the presence of an undue

TABLE 28.—THE EFFECT ON THE ATTENDANCE OF INTRODUCING A PURE MILK SUPPLY TO THE U. S. NAVAL ACADEMY

| Year | Average attendance at the Academy | Number of sick days due to intestinal disorders | Cases of typhoid fever |
|---|---|---|---|
| October, 1910–Sept. 30, 1911 | 759 | 1,598 | 29 |
| October, 1911–Sept. 30, 1912 | 860 | 296 | Typhoid prophylactic used on brigade. |
| October, 1912–Sept. 30, 1913 | 875 | 253 | |
| October, 1913–Sept. 30, 1914 | 914 | 228 | |
| October, 1914–Sept. 30, 1915 | 922 | 270 | |

TABLE 29.—REDUCTION OF INTESTINAL DISORDERS CONSEQUENT UPON INTRODUCING A PURE MILK SUPPLY TO THE U. S. NAVAL ACADEMY

| Year | Sick days due to intestinal disorders | | Remarks |
|---|---|---|---|
| | October | November | |
| 1910 | 184 | 840 | Milk secured by contract only. |
| 1911 | 53 | 60 | In every month, save two, milk wholly from Academy. |
| 1912 | 0 | 19 | Milk wholly from Academy herd. |
| 1913 | 22 | 6 | Milk wholly from Academy herd. |
| 1914 | 23 | 25 | Milk wholly from Academy herd. |
| 1915 | 16 | 16 | Milk wholly from Academy herd. |

amount of typhoid fever and minor intestinal disorders among the midshipmen and the difficulty of getting contract milk that was produced under fit sanitary conditions led to the establishment of a dairy with a herd of 90 cows selected by the Bureau of Animal Industry. A new barn was built and a determined and successful effort was made to keep flies out of it.

The Academy supply was first served the midshipmen on October 1, 1911, but a part of the contract supply was continued in use for 2 months. The young men are in prime physical condition and their diet is controlled, yet a remarkable reduction in absences from classes was obtained when they were given the milk from the Academy herd. No other change in the food was made and the authorities attribute the improvement shown in Tables 28 and 29 solely to the improved milk supply.

**Diseases of Class II.**—The second class of diseases transmitted in milk, is made up of certain infections derived from man and comprises typhoid fever, paratyphoid fever, Asiatic cholera, diphtheria, scarlet fever, and septic sore throat. Of all the diseases of this class it may be said with assurance that the recorded number of milk-borne epidemics is decidedly less than actually have occurred. This is partly because many epidemics are never investigated, and partly because health officers and others often do not regard epidemics which they have throttled to be of sufficient general interest to write up. In other cases local pride and business interests may keep outbreaks quiet.

In very few instances has the specific disease germ been isolated from the suspected milk. This is usually because the game is not worth the candle; in most cases the bacteriological technique is tedious and uncertain but of at least equal moment is the fact that whereas the milk supply is not apt to remain infected for more than a short time the incubation period of the disease may last several days or even 2 weeks so that the disease germs disappear from the milk before the contagion breaks out. Then, in the case of scarlet fever, the specific organism is unknown. So, epidemiological methods are chiefly relied on to detect sources of infection and to nip budding epidemics.

**Typhoid Fever.**—Typhoid fever is a communicable disease that is spread by direct contact and by infected water, milk, oysters and other foods, and by flies. The relative importance of these several modes of dissemination varies in different places but everywhere that it is consumed raw, milk is more than likely to be an important factor in spreading the disease. In some localities it may take first place as a disseminator; this is apt to be so where other causes have been largely eliminated. Thus in 1907 Harrington stated that in Massachusetts, where pure water supplies are the rule, for the 2 years past, 14 out of 18 outbreaks of typhoid fever were due to milk.

Milk is a very common source of typhoid infection; Trask and a few

workers mentioned by him have collected from literature somewhat over 500 epidemics of typhoid fever that were milk-borne. In the United States apparently the first recorded outbreak of typhoid fever that was attributed to milk was that at Allegheny City, Pa., in 1882 but it was not till about 1889 that the reporting of such epidemics became common. Trask's own list is composed of 179 epidemics of which 107 were in the United States, 43 in Great Britain, three in Continental Europe, three in Australia, one in New Zealand and two in Canada. There are several ways of accounting for the preponderance of cases in this country but the fact that raw milk is more generally used here than abroad is outstanding.

Typhoid fever may be transmitted in milk products as well as in whole milk. In Kober's list of epidemics there are three that occurred in Ireland during 1892–96, that were conveyed by skim-milk returned to farms from creameries. In some cases whole milk was infected on the farm of patrons and was mixed with that of others at the creamery while in other instances the milk was infected by creamery employees. The group of cases is interesting for in these days when the attempt is being made to persuade legislatures to protect cattle and hogs from foot-and-mouth disease and tuberculosis by enacting laws requiring the pasteurization of skim-milk and whey at creameries and cheese factories before its return to the farm, additional force is lent the argument by pointing out that such laws would also protect human beings from contagion. In this country Sedgwick in 1894 traced an epidemic in Marlboro, Mass., to skim-milk from a creamery.

The experiments of Mitchell show that *B. typhosus* can be recovered from inoculated frozen cream after 3 weeks or more. Ice cream has been held responsible for typhoid epidemics; four have been recorded in Great Britian and two in the United States. The first of those in this country was reported by Horton from Montclair, N. J., in 1894.

Butter is recognized as a possible medium of transmission of typhoid fever but there seem to be no recorded epidemics due to it. Bruck infected milk with *B. typhosus*, separated it and was able to find the organism 10 days thereafter in both the buttermilk and cream. In butter made from this cream he recovered the bacillus after 27 days. Other workers have obtained similar results. Typhoid fever germs certainly live long enough in butter for them to reach the consumer in a virulent condition so that if butter is made from infected milk or cream, typhoid cases may be expected among those who eat it. However, there are several reasons that diminish the probability of butter becoming a distributor of typhoid fever. In the first place, it should be recognized that the process of manufacture plays a part. Butter may be made from pasteurized cream, from sweet cream or from sour cream, it may be salted or unsalted. Butter from pasteurized cream is perfectly safe if the pasteurization has been properly done and the cream is not subsequently infected. Unsalted

butter from sweet cream is most likely to be dangerous for it receives the benefit of no inhibitory principles other than those inherent in itself, namely, that it is a solid medium containing comparatively little moisture. Salt is mildly antagonistic to microbial life, but the salting that butter receives is never heavy.

**Effect of Lactic Acid on Disease Germs.**—The greatest protection is in the acids, and possibly other products, formed by the lactic acid bacteria in souring the cream. Many experiments have been made to measure the germicidal effect that souring cream has on the typhoid bacillus. Some observers have found no such action but the latest experiments indicate that it is very considerable, that it reduces the number of typhoid bacilli but cannot be relied upon to kill them all.

Krumwiede and Noble found that the typhoid bacillus is gradually killed in sour cream by the acids produced, the rate of destruction being proportional to the degree of acidity and the number of typhoid bacilli present. With moderate contamination the typhoid bacilli are killed in about 4 days, but with heavy contamination, or when initial multiplication has taken place, it may take longer.

Heinemann found that "some acid tolerant cells of *B. coli* may survive the presence of 0.6 per cent. lactic acid in milk." *B. dysenteriæ*, *B. typhosus*, *B. paratyphosus β*, *Sp. choleræ*, and *B. diphtheriæ* in the experiments were destroyed in the presence of 0.45 per cent. lactic acid. It is possible that strains of these bacteria exist which are able to resist a greater amount of lactic acid. Acid tolerant strains of *B. coli*, *B. dysenteriæ*, *B. typhosus* and *B. paratyphosus β*, may multiply in the presence of quantities of lactic acid which are destructive to the majority of cells. The smaller the initial amount of lactic acid, the more likely is the growth of acid-tolerant strains to occur. Therefore, the slower milk sours the greater is the danger of pathogenic bacteria surviving.

The growth of the test bacteria is influenced to a marked degree by the amount of acid present. Up to a fairly definite amount of acid there is an increase in numbers, followed by a decrease, which becomes more pronounced as the amount of acid increases. The amount of acid may increase owing to the liberation of enzymes, after the number of bacteria has commenced to decrease.

**Possible Infection of Butter in Wrapping.**—There is opportunity for butter to be infected by those who work it after it is made. It is commonly shipped from creameries to the large cities in tubs, and is there put up in prints or packages for sale. This necessitates more handling and by another set of employees. Perhaps this last process is not the least important, for the butter reaches the public soon after being wrapped, whereas at other stages in its progress to the consumer, it is held in cold storage and opportunity is given the germs to die out. However, many prints are wrapped by machine and are handled little in the process.

Buttermilk is commonly sold soon after it is made, so that while it undoubtedly is to a considerable degree antagonistic to typhoid germs, the possibility of its containing them must be conceded. Fraenkel and Kister believed that the unusual amount of typhoid fever at Hamburg, Germany, in 1897 was in part due to infected buttermilk. Heinemann found that acids other than lactic acid are frequently present in buttermilk. Since these acids may not be as strongly germicidal as lactic acid, it should be looked upon with suspicion, especially if heavily polluted, unless prepared from pasteurized milk. Still, the chance of buttermilk becoming the carrier of infection is much less than of raw sweet milk. "The presence of saprophytic bacteria in buttermilk may have some influence on pathogenic bacteria. Whether this influence is favorable or otherwise is difficult to determine by present bacteriological methods."

Typhoid bacilli have been shown to be recoverable from artificially infected cheese after some 3 weeks. The period would probably vary with the type of cheese. Unless cheese should be made of infected milk and eaten soon afterward as cottage cheese and some others might be, there is little likelihood of contracting typhoid from this source.

**Paratyphoid Fever.**—Paratyphoid fever is spread in the same way that typhoid fever is. Dr. F. G. Curtis reported an outbreak of the disease in Newton, Mass., in 1912. In all there were 25 known and three probable cases; of the known cases; 15 gave positive agglutination tests with $\alpha$-paratyphoid bacilli. Everyone of the 25 patients used the suspected milk. The original infection of the milk occurred on one of the dairy farms that supplied the implicated route but there was reason for believing that later some of the milk was infected by an employee of the retailer, who had contracted the fever by drinking the infected milk from the dairy farm. In the affected communities no cases of typhoid fever and no other cases of paratyphoid fever were reported within the period under consideration.

At Ames, Iowa, there occurred a milk-borne epidemic of paratyphoid fever in which the patients' sera indicated *B. paratyphosus* $\beta$ as the infecting organism. Ten cases were discovered and nine of the patients were patrons of a single milk dealer. The primary source of the contagion was held to be either a carrier or a convalescent.

**Asiatic Cholera.**—Asiatic cholera is caused by *Sp. choleræ* which is discharged in the feces of the sick and of carriers; it is readily spread by fingers soiled with such evacuations, by flies and in every way by which transfers are made of even infinitesimal amounts of infected matter, to food and to other objects that afterward find their way to the mouth of man. It is man-borne and dogs the footstep of pilgrims, caravans, emigrants and armies. It is often spread from port to port by carriers. Drinking water is frequently infected with it and has

caused serious epidemics. The vibrio requires a neutral or slightly alkaline medium for growth and apparently for this reason milk has played a less prominent part in its spread than has other food, since, as in typhoid fever, the lactic organisms exert a protective action. Alexandrine and Sampeto found that the limit of acidity the vibrio will stand in milk is less than 1 per cent. calculated as lactic acid. In their experiments the cholera vibrios lived in ordinary milk at room temperature 11 to 63 hours or until prohibitive acidity had been reached. At 98.7°F. the vibrios usually disappeared in 6 to 8 hr. Kendall, Day and Walker found that in pure culture the vibrios produced acid coagulation of milk by the end of the third day.

Simpson, the health officer of Calcutta, reported that nine cases of cholera occurred on a ship there, 10 of whose men had obtained milk from a native. One drank but little of the milk and escaped, four died of cholera and five were very sick with diarrhea. Eight others who had condensed milk only and who did not touch the suspected milk were not ill. Dejecta from a cholera patient found access to a water tank near the dairy and the milkman confessed diluting his milk one-fourth with water from the tank.

Heine and others have shown that the cholera spirillum soon dies out in butter and he failed to find the organism after 1 or 2 days in cheese.

The paucity of well-authenticated epidemics of this disease attributable to milk, together with the other facts that have been given regarding the limited life of the vibrios in milk and its products, indicate that relatively milk is not an important factor in disseminating the disease.

**Diphtheria.**—Diphtheria is caused by *B. diphtheriæ* and is spread in the secretions of the mouth and nose. Droplet infection and infection from objects mouthed or handled either by those ill with the disease or by bacillus carriers are common modes of infection. Milk is often the medium through which the contagion is spread. The first epidemic in the United States attributed to milk seems to be that in the cities of Malden and Melrose, Mass., in 1886. Hart and Busey, and Kober list 28 milk-borne epidemics and Trask 23, making 51 in all; many others must have occurred. Of Trask's outbreaks, 15 occurred in the United States and eight in Great Britain.

**Scarlet Fever.**—Scarlet fever seems to be spread in the secretions of the nose, throat and respiratory passages and in purulent discharges from the ears. Hart and Busey, and Kober list 74 epidemics due to milk; to these may be added 51 gathered by Trask, making 125 in all. Of Trask's 51 outbreaks 25 were in this country and 26 in Great Britain. The first recorded outbreak attributed to mllk in the United States appears to be that at Putnam, N. Y., in 1890.

**Septic Sore Throat.**—Is a malady that is characterized by a sudden onset, high and irregular fever, inflammation of the fauces, marked en-

largement of the cervical glands, particularly in the case of children and a course much longer and attended with many more complications than the usual types of tonsillitis. The joints often are affected and the heart and kidneys seriously damaged; middle ear disease and erysipelas may appear, pneumonia and peritonitis sometimes develop and terminate fatally. In the principal epidemics that have been studied in this country the incidence of the disease has been greater among females than males. In the Cortland-Homer epidemic 57 per cent. of the cases were of females; in Concord 58 per cent.; in Baltimore 58 per cent., and in Rockville Center 59 per cent. In the Baltimore epidemic the fauces appeared to be the portal of entry but in some cases there was some question whether entrance to the body was not obtained in some other way. The disease is now recognized to be caused by a $\beta$ hemolytic streptococcus of the Smith type. The incubation period is about 3 days; the length of illness varies with the severity of the attack and the complications that develop.

Savage's list of outbreaks of septic sore throat shows that extensive epidemics occurred at Guilford and Colchester, England, and at Christiania, Norway, before the disease was recognized in the United States. Here, septic sore throat was first known as such and studied by modern methods in the epidemic that occurred in Boston, Mass., in 1911. Winslow who made a study of the epidemic pointed out that before the Boston outbreak occurred the disease prevailed in prosodemic form in the region where the infected milk was produced and he has described an epidemic that occurred in Westchester County, New York, which was also prosodemic but on which a milk-borne outbreak was superposed, and Frost in the Baltimore epidemic attributed some cases to this mode of dissemination. So the disease is not necessarily caused by infected milk; it may be spread by contact infection. This accords with what is now known of the bacteriological aspect of the disease for the Smith streptococcus is primarily a human infection; it causes carrier cases and it infects milk chiefly by being transferred through the teat canal and wounds to the udder of the cow where it proliferates and causes massive infection of the milk which gives rise to the widespread epidemics that have focussed attention on the disease. In one instance a bottle infection has been described and it has been held that milk has been infected by an infected person who handled it. Much patient investigation has been required to reach this correct understanding of the disease for at first, owing to the fact that the causative organism was a streptococcus and that mastitis was known to be often caused by streptococci, suspicion was directed to the cow and all garget cases were regarded as potentially dangerous, although herdsmen and others who were familiar with cows thought it improbable that mastitis which is so common could more than very exceptionally be the cause of contagion. Mistrust of the udder-sick cow was deepened by the discovery of cases of mammitis in some of the herds

supplying the infected milk, though in some instances the presence of sore throat in the family of the proprietor raised the question whether these throats bore any relation to the epidemic, and if so whether they were the cause of direct infection of the milk, or of indirect infection by infecting the udders, or whether they were not themselves derived from the cases of garget in the herd. So the questions of whether the cow was infected by humans and of the pathogenicity to man of the streptococci causative of garget were raised.

The investigations and experiments of Savage in England, of Ruediger, and of Davis and Capps in this country were important in helping to solve these questions, for, taken together, they indicated that the streptococcus, which is ordinarily the cause of garget, is not pathogenic for man, that the blood agar plate may be used to distinguish *St. lacticus* from *St. pyogenes,* which is found in human throats, and that cows cannot be infected with streptococci of human origin by smearing them on the udder, but that they may be, either by abrading the teat slightly near the teat canal and applying the cultures, or by injecting them a short distance into the udder.

**Study of Smith and Brown.**—Theobald Smith and J. H. Brown studied hemolytic streptococci associated with outbreaks of milk-borne tonsillitis in five Massachusetts cities, and compared them with those isolated in other epidemics. They point out that mammitis is a disease that is due to injury and subsequent infection of the udder and that it is prevalent at all seasons of the year, whereas septic sore throat prevails mostly in the transition period between winter and spring when throat affections in man are common, and furthermore that in septic sore throat outbreaks due to milk, the milk remains infected for a long time. They suggest that the grafting of human streptococci on the udder in milking and in otherwise manipulating the udder, and their subsequent development therein afford a reasonable explanation of outbreaks of the disease. There is no evidence that the streptococci that are responsible for garget are the occasion of outbreaks of septic sore throat but it is conceivable that in an inflamed udder both bovine and human streptococci might be found, in which cases the latter should be regarded as an added infection. The observations of Smith and Brown and of others indicate that when infections of the udder with human streptococci do occur, physical manifestations in the udder are very slight if noticeable at all.

As a result of their research these two investigators isolated two streptococci that they held responsible for septic sore throat. One, outbreak A, was altogether singular, in that the fermentations it produced with sugars were different from those produced by streptococci that caused the other outbreaks which they studied. These latter proved to be identical with the streptococci that caused all the epidemics investigated by others.

The other streptococcus was isolated in one outbreak, from a cow in the suspected herd and was different from hemolytic udder streptococci in the same herd and from those of the herd in outbreak A.

The udder of this cow had been injured and one quarter which was inflamed gave a thick curdy product; the three other quarters were apparently unaffected but the milk from the inflamed quarter did not give hemolytic streptococci in the cultures, whereas the mixed sample of milk from the three quarters that seemed sound contained human streptococci. This type was wholly identical with streptococci from the throats of three human cases, one of them fatal, and in another outbreak it was isolated from mixed milk. This organism is now regarded as the usual cause of septic sore throat and is referred to as the $\beta$ hemolytic streptococcus of the Smith type or briefly as the Smith streptococcus. The strains studied differed slightly among themselves, as to form of the colonies and other cultural characteristics. On horse-blood agar plates the colonies formed a sharply defined, clear, transparent, completely hemolyzed, colorless zone 2 to 4 mm. in diameter; they were simple and biconvex and never complex. In bouillon the growth of the several strains varied from a well-clouded suspension with flocculent sediment to a perfectly clear bouillon with abundant fleecy sediment. The great clouding was associated with the shorter chains. In 7 days, cultures in milk coagulated on heating. In bouillon after 24 hr. incubation, the chains were composed of round flattened cells, that is, with the transverse axis the greater with occasional cells that were elongated. This streptococcus fermented dextrose, maltose, saccharose, lactose and salicin with the production of acid, but did not ferment mannit, raffinose or inulin. Injected intravenously into rabbits in a definite, uniform dose it produced a febrile reaction lasting 1 to 4 days or over a week, followed by, or accompanying, a localization affecting the hip, shoulder, knee, wrist, and foot. In the more acute cases foci occurred in the kidneys and heart. These streptococci were identical with streptococci that were held by other bacteriologists to be causative of the epidemics of septic sore throat in Boston in 1911, and Baltimore and Chicago in 1912 which were found to be identical with each other.

The streptococci that have caused the recent outbreaks of septic sore throat are alike in that immediately around the colonies is produced a clear hemolyzed area on blood agar plates; but these hemolytic colonies are to be carefully distinguished from the colony of the common throat coccus, which has a partly discolored and hemolyzed mantle between the colony proper and the outer, narrower hemolyzed zone.

**Study of Krumwiede and Valentine.**—This work was amply confirmed by Krumwiede and Valentine who investigated an outbreak of septic sore throat that occurred at Rockville Center, Long Island, N. Y., in June, 1914. The infection was on the route of a dairy that daily

distributed 400 qt. of milk to 175 customers. All the other dairymen together distributed 1,200 qt. of milk. The infected dairy had 205 out of 232 cases; therefore, though it delivered but 25 per cent. of the milk, it had at least 90 per cent. of the cases. Most of the milk of the infected dairy came from a herd of 22 cows at Oceanside but in part the milk came from two smaller dairies, R and C. All three of them were investigated.

At Oceanside it was found that the daughter of the owner, Miss W., developed sore throat on April 16. Her mother came down with it on May 9; she claimed to have been absent from the dairy until May 28. A driver took the disease on May 11 and a milker on June 9. The greater part of the milking was done by the owner and a milker but the driver sometimes helped. On April 21, May 17 and May 21 isolated cases of sore throat appeared among the customers. On May 30 two cases appeared in a family that had its own cow; these cases and those at the farm seem to have been of sporadic and contact origin.

The material that was examined bacteriologically consisted of moist swabs from the throat of every individual on the three farms supplying the infected dairy and from a number of cases, as well as from a culture from a complicating case of peritonitis. Milk from each quarter of all the cows was put on ice over night and smears from the sediment were examined.

Five of the cows showed moderate numbers of streptococci in one or more quarters and one of the animals gave physical evidence of mastitis. Another cow showed moderate numbers of streptococci in two quarters and enormous numbers of streptococci from one-quarter. Milk from this quarter, owing to coagulation of the casein and separation of the whey, was flocculent.

All positive samples of milk were inoculated on blood agar plates. The cultures from cows 2, 3, 4, 5 and 6 showed: on blood agar plates, no hemolyses; on washed blood cells, no hemolysis; no fermentation of inulin, raffinose, and mannit; fermentation of salicin. The milk from three-quarters of cow 21 showed: hemolysis of blood agar plates; hemolysis of washed blood cells; no fermentation of inulin, raffinose, and mannit; fermentation of salicin.

Twelve cases of septic sore throat were studied and hemolytic streptococci in varying percentages were found present. Pure cultures were isolated from each case and usually not only several hemolyzing but also several non-hemolyzing types were found. At the Oceanside dairy hemolyzing types were obtained from the driver, milker and a wash-woman who had enlarged tonsils but denied illness; no hemolyzing types were obtained from Mrs. W. At Farms R and C there had been no cases of illness and no hemolyzing types were found except from Mrs. R. who had enlarged tonsils. The non-hemolyzing types were studied only in

relation to similar ones isolated from the five cows. Most strains could be excluded because of fermentative and other reactions. Very few had characteristics of the bovine strains and nearly all came from the non-exposed on farms R and C; consequently the non-hemolyzing strains were excluded from consideration as the caustive organism.

The hemolyzing types obtained from the throats of the cases, from the throats of persons at the Oceanside dairy and the culture from a complicating case of peritonitis, had the same cultural characteristics and were similar to the hemolyzing strain from cow 21. But one hemolyzing strain was isolated from the non-exposed, to wit, from Mrs. E. R. on farm R, but this strain, though it gave the same sugar fermentations, was different from the other hemolyzers in other cultural reactions, its morphology and other characteristics.

The isolation of a distinct race of streptococci from the throats of the cases, from a complicating peritonitis and also from the throats of persons and from a cow on one dairy farm, together with the absence of this streptococcus in the throats of persons on other farms, when considered in connection with the epidemiological data, viz., the presence of sore throat on the one farm before the general outbreak, makes it practically certain that the following sequence of events occurred. Miss W., was infected on April 16 and by contact infection gave sore throat to Mrs. W. on May 9. From one of the two the driver became infected on May 11 and either he or Mrs. W., probably the latter, infected the cow. Multiplication of the organism in the milk ducts and in the milk itself with contamination of the mixed milk occurred, culminating in the outbreak.

"Therefore it is concluded that the facts give strong added evidence to the view that infection in milk-borne septic sore throat is of human and not of bovine origin. The fact that the cow infected with 'human' streptococci had no physical evidence of mastitis whereas another cow having mastitis yielded another unrelated 'bovine' variety of streptococcus is also of value as evidence in this connection. Previous investigations have shown that some types of 'human' streptococci can multiply for a shorter or longer period in the udder without producing evidence of mastitis."

Krumwiede and Valentine conclude that:

"Streptococci, similar culturally and identical in their agglutination, were isolated from cases of septic sore throat and from the udder of one cow which showed no evidence of mastitis, except the peculiar character of the milk from one-quarter. Both the bacteriological and epidemiological facts show that the infection was primarily of human origin. The streptococci in the various epidemics, including this Rockville Center epidemic, have all been the same culturally with one exception, namely 'outbreak A' of Smith and Brown. In tracing the source of such an epidemic, the effort should be toward finding cases of sore throat among those engaged in producing milk, not mastitis in the cow alone.

If human streptococci are found in mastitis, they are most likely secondary agents in an already existing inflammation due to bovine strains. The streptococci in different epidemics differ culturally and those similar culturally differ in their immunity reactions. Cultural similarity of strains from man and cattle is insufficient to prove their identity; cultural identity in every detail or immunological identity is essential."

In the course of the investigation the following practical points were developed: (1) Few hemolytic types may be found even when the swabs are directly inoculated upon blood agar; they may be lost on Loeffler blood-serum smears submitted for examination. (2) On surface streaked blood plates, typical hemolytic colonies may not be present, though on longer incubation they may develop. (3) For the determination of sugar fermentation, serum water is unsuited. All of the type strains failed to ferment salicin, using this medium, although prompt fermentation took place using serum broth or serum water containing 1 per cent. of peptone.

**Studies of Smillie.**—In forthcoming work, now in press, Dr. W. G. Smillie develops the following points:

1. His investigations of epidemics of septic sore throat confirm the work of Smith and Brown.

2. Though the Smith streptococci usually disappear from the throat of the patient within 3 weeks after the passing of the clinical symptoms they may persist for 4 months and possibly longer.

In a small outbreak in a hospital he discovered the source to be a nurse who 4 months before had contracted the disease in a milk-borne epidemic and who as a carrier was conveying the disease to others by contact infection.

3. Out of 100 normal throats examined, 60 per cent. being those of adults and 40 per cent. those of children, but one yielded the Smith streptococcus.

He studied the throats of 25 persons who within 2 years had suffered attacks of milk-borne septic sore throat and among them found but one carrier, the nurse in the hospital.

4. In a study of 25 cases of ordinary tonsillitis he found that about one-half were due to the Smith streptococcus. Tonsillitis on the dairy farm, therefore, should not be regarded lightly, for it may be the source of serious milk infection.

5. In a study of scarlet fever cases he found that most severe cases, and some of the moderate and mild cases harbored the Smith streptococcus in their throats. He believes that a case of scarlet fever may infect the milk or the udder of the cow with Smith streptococcus. So there may result from a scarlet fever case milk-borne cases of (*a*) scarlet fever, or (*b*) septic sore throat or (*c*) a mixed infection of the two.

**Summary of Epidemics.**—In Table 30 are set forth some of the leading facts concerning the principal epidemics in this country. The widespread serious character of the outbreaks, taken into consideration with the fact that in many of them the management of the dairies was more than usually intelligent and conscientious, convinced the experts who investigated them that the health of milk consumers could be effectively protected only by pasteurizing the milk under thorough inspection.

TABLE 30.—PRINCIPAL EPIDEMICS OF SEPTIC SORE THROAT IN THE UNITED STATES

| Date and place | Number of cases | Males | Females | Deaths | Age distribution, percentage of cases in each age period, years | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Below 11 years | 11–20 years | 21–30 years | 31–40 years | 41–50 years | Above 50 years |
| May, 1911, Boston, Mass. | 1,043(*a*) | 215 | 522(*c*) | 48 | (*b*) | ... | ... | ... | ... | ... |
| Dec. 2 to May 10, 1911, Baltimore, Md. | 1,000–3,000 | 201 | 383(*d*) | 30 or more | 53 | 12 | 15 | 10 | 6 | 5 |
| December, 1911, to February, 1912, Chicago, Ill. | 10,000 | .... | ...... | ....... | ... | ... | ... | ... | ... | ... |
| Jan. 1 to Feb. 15, 1912, Concord, N.H. | 1,000 | 119(*e*) | 162(*f*) | ....... | 18 | ... | 42 | 22 | ... | 18 |
| April 20 to May 10, 1913, Cortland-Homer, N. Y. | 669 | 286 | 383 | 14 | 15 | 16 | 18 | 19 | 13 | 20 |
| June, 1914, Rockville, N. Y. | 232 | .... | 147 | ....... | 29 | 13 | 22 | 20 | 9 | 8 |
| January to May, 1915, Weschester Co., N. Y. | 905 | 376 | 517 | ....... | 25 | 16 | 20 | 21 | 11 | 6 |

(*a*) Including Brookline and Cambridge.

(*b*) Figures for Cambridge alone; under 15 years, 15; 16 to 25 years, 20; and over 20 years, 64.

(*c*) 306 patients whose sex is unknown.

(*d*) 85 patients of unknown sex.

(*e*) Besides these were 128 boys in St. Paul's School.

(*f*) Besides these there were 25 girls in St. Mary's School.

**Mode of Transmission of Infectious Disease.**—Having named the diseases that are transmitted by milk, the ways in which they infect it must be considered. In the first place, it should be recognized that there are two sources of danger, animals and men. Of these the former are the least important for, with the exception of septic sore throat, which primarily is of human origin, and of bovine tuberculosis, not many of their diseases are communicable to man and those that are so are relatively rare. The virus of a few of them such as tuberculosis, foot-and-mouth disease and septic sore throat are in the milk as it comes from the udder. Tubercle bacilli also are contained in the feces of diseased cows which dropping into the milk infect it. Milk may also be infected by droolings from the animals and by pustular and vesicular

discharges from eruptions on the udder. All such infectious matter may be carried to the milk on the hands of uncleanly careless milkers.

The virus of human disease is contained in the urine and excrement and in the discharges of the mouth, nose and ears of those who have communicable disease. Epidemiologists distinguish several states in which people may disseminate contagion. There are those in the prodromal stage, that in which the malady is developing in their system. Such people may infect the milk; in typhoid fever, for instance, the victim may eliminate the specific germs for as long as 10 days before the premonitory symptoms appear. There are those who are actually sick. They form two groups; those who are severely ill and so betake themselves to bed and those with mild or walking cases, who feel mean or perhaps only excessively tired so that they do not give up work but continue thereat as usual. Of these two groups both are dangerous but the latter are very much more so than the former for they can hardly avoid infecting the milk if they have to handle it. From this group the "missed" cases arise, cases so very mild that their existence is never detected. They form an important source of communicable disease and at least one widespread milk-borne epidemic has been ascribed to such an origin. Finally there are the carriers of which there are three sorts, the acute, the chronic and the temporary. An acute carrier is one who discharges pathogenic microörganisms for a few weeks after recovery. Such a one, on returning to his duties, may be the cause of an outbreak. The chronic carriers are those who for months or years after recovery harbor and scatter about the germs of the disease that affiicted them. Sometimes intermittent chronic carriers are spoken of; the appelation signifies that they discharge the specific germs for a while and then stop doing so only to begin again later. It is only of late years that the existence of carriers has been recognized but they are now and the number of outbreaks that are traced to them increases steadily. The temporary carriers are those who never have had communicable disease themselves but who by contact with those who have, become for a short time distributors of infection. To this class belong those who in nursing the sick infect themselves but do not develop an attack of the disease.

Finally, contagion is spread by flies that feed on the discharges of the sick and afterward carry the germs on their feet and droppings to milk and other foods.

**Transmission by Milk.**—Milk may be infected at various stages of its progress from the cow to the consumer, on the farm, in transit, at the city milk plant, in stores, and in the home. The possibilities of infection are taken up in detail.

**Infection of Milk on the Farm.**—It is conceivable but not probable that cows wading in infected streams might infect their bellies and udders with disease germs that would fall into the pails at milking. No flawless

examples of this having happened can be cited, yet instances are known where cities have forbidden the delivery of milk from certain farms whereon the cows had access to heavily polluted streams.

Commonly infection at the farm is caused by some one living thereon contracting the disease and either directly himself or indirectly through his attendants infecting the milk. It is of prime importance to inculcate cleanly habits among those engaged in dairying. They should be told frankly that nasal discharges, saliva, feces and urine are all likely to be infectious and that decency and safety alike require them to refrain from spitting on the hands at milking and from blowing the nose with the fingers. Above all the necessity of washing the hands after attending to the toilet should be impressed upon them. The part played by feces, fingers and flies in distributing infection should be carefully borne in mind. Of epidemics originating at the farm a brief account of a few will serve as examples.

Milkers caused an outbreak at Brookline, Mass. Two of the dairyman's children came down with diphtheria and were removed to a hospital. No diphtheria bacilli were found in other members of the household. Three weeks later cases of diphtheria began to appear in Brookline in four of the seven or eight families that used the milk. Reëxamination of the members of the family and of others handling the milk showed virulent diphtheria bacilli in the throats of three men, of whom two were at the time milking the cows.

Persons who nursed the sick and also cared for the milk caused 16 cases of typhoid fever at Washington, D.C., in 1905; half of the cases were in the family on the farm.

A mother who nursed members of her family sick with typhoid fever and also milked the cows caused 55 cases of that disease at Philadelphia in 1903.

Milk may be infected at the farm through contact with milk utensils such as brushes, strainer cloths, cans, coolers, separators, etc., which have been infected either by the sick or those nursing them. At Providence, R.I., 1895, 31 cases of typhoid fever and three deaths were caused by a mother who was nursing the sick, washing the strainer cloths and utensils. At Lynn, Mass., in 1906, 31 cases of typhoid fever came from a boy ill with the disease washing the bottles. A person who washed the cooler of a dairy and at the same time cared for a child sick with diphtheria caused 72 cases of that disease in 1907 in Milton, Dorchester and Hyde Park, Mass.

Water supplies on farms and in milk plants are often held responsible for typhoid fever outbreaks. Water that is used for washing utensils, cooling the milk or diluting it, may be the source of trouble. The outbreaks that have been attributed to washing utensils with polluted water are very many. Fourteen cases at Swampscott, Mass., in 1905

are believed to have come from washing cans in polluted water. Eleven of the cases were supplied by one dairyman who received milk from several farms. In the family of one of them, were two cases of typhoid and of another three. At one of the farms a pail used for discharges of the patients was kept on the curb of a well the water of which was used to wash cans. At York, Pa., in 1899, 66 cases of typhoid fever and 14 deaths were caused by milk that is believed to have been infected by washing cans in the water of a spring near which typhoid dejecta were thrown.

An epidemic in 1892 at Springfield, Mass., of 125 cases of typhoid fever was attributed to milk which had been cooled in a polluted well by sinking the cans to the bottom where they were covered by 3 or 4 ft. of water and remained for hours at a time. As the stopples did not fit tight the cans filled with the polluted water. While this is rather a gross example of the careless cooling of milk no one who has observed the manner and places of cooling milk on many dairy farms can doubt that a warning against this sort of carelessness is needed. At Palo Alto, Cal., in 1903, out of 900 customers of one dairy 232 had typhoid fever and all but 16 of these cases were primary; the milk cans were washed and the milk adulterated with water from a sewage-polluted creek.

But one epidemic, that at Hartford, Conn., is attributed to the use of infected ice in the dairy; it is doubtful if even this case would bear close scrutiny in the light of the most recent knowledge of the ways in which contagion is transmissible. Ice is an unfavorable medium for bacteria; it has been shown that 40 per cent. of the typhoid bacilli die within 3 hr. after freezing and 98 per cent. in 2 weeks. Still, such infection is conceivable and at the time the epidemic was investigated it was believed to be due to the ice which was cut on a contaminated pond. There were 30 cases and four deaths from typhoid fever among the customers of the dairy and they occurred only among those that used the evening milk. This milk was submerged over night in ice water; it was only a little while before the epidemic began that this ice was used.

Occasionally the infection is brought to the farm by children or visitors. At Rockford, Ill., in 1913, a dairy route was thought possibly to have been infected by a neighbor's child who had walking typhoid fever and who was permitted to cap the milk bottles. In Norwalk, Conn., a scarlet fever outbreak appeared in 1897 that was due to an infected milk supply. The contagion was traced to one of three dairy farms that supplied the Norwalk dealer. It seems that there had been a contact epidemic of scarlet fever in the district school and that among those who caught the disease were two children that lived near the dairy farm. The cases were very mild and the youngsters visited the farm and played with the dairyman's child who ultimately took the fever. The milk was believed to have been infected in some way by the children.

As long ago as 1895, Kober pointed out that the house fly might infect milk; since that time knowledge of the habits of that insect has increased and it is generally recognized to be a factor in spreading typhoid fever, tuberculosis and other diseases. By preference it lays its eggs in horse manure, but it also oviposits in human excrement and cow dung. Furthermore, it feeds on human dejecta so that it carries away from the ordure on its bedraggled legs and in its infected intestines such disease germs as happen to be therein and it tracks or drops them on whatever it happens to alight. Flies also have the habit after feeding on liquid food of exuding drops of fluid from their proboscides. These drops are sometimes sucked up again and sometimes are deposited on the surface on which the flies are walking. This deposited material is derived from the fly's crop; it is sometimes called "vomit" and may be infectious. In feeding on dry material the fly moistens it with vomit or saliva; this is done for instance when it feeds on sugar. Flies swarm about milk pails, in stables and in milk houses and wherever milk is handled, so that great care should be taken to screen such places and to fight the flies with sticky fly paper, traps, etc., but poison fly paper should not be tolerated about a dairy. While it is difficult to prove that flies have infected the utensils or milk of any dairy it is a fact that they have been strongly suspected of doing so. Consequently great care should be taken to make privies on dairy premises flyproof. Also, employees should not be allowed to defecate on the ground near the dairy nor should stools be thrown on the manure heap. Likewise, the house slops should be properly disposed of and not thrown out on the ground where flies can get at them.

In some dairies cats are given free run of the barns to catch mice; they are apt to be much in evidence at milking time and are not slow to get at a pail of milk that a milker sets down for a moment. Rarely, cats become infected with diphtheria and possibly other disease and there is a bare chance that this might happen with unhappy consequences in a dairy.

**Infection of Milk Enroute to the Creamery or City.**—After milk leaves the farm there is the chance that it may be infected on the way to the creamery or railroad station or in the course of the journey to the city if the cans in which shipment is made are unsealed. In some communities milk is picked up from several farms by a single driver and hauled to its destination. There is apt to be more or less shifting about of the cans on the trip and there may be some dumping of milk from one can to another so that if the handler should happen to be a carrier or diseased, the milk might get infected.

On the trip to the city unsealed cans are apt to get opened and the contents may even be sampled by the curious. This is more likely to happen in trolley and baggage cars to which the public has access than

in regular milk cars. In some cases the cans are transferred from one train to another and if this is done carelessly the milk may be exposed to pollution and perhaps infection. However, if milk is infected in these ways it is only infrequently, but the possibility of such mishap should be recognized and guarded against.

**Infection of Milk in the City Milk Plant.**—In the city milk plant, milk is exposed further to accidental infection. It is customary at many plants to taste the milk before accepting it in order to prevent any which is off flavor being included in the daily output. Where the milk is simply smelled, or tasted from a cup, which is filled with a ladle there is no danger but where the cup is dipped into the cans there is danger that the milk may be infected either from the fingers or saliva of the tester.

Afterward in the dumping of the milk from the cans into vats and in the course of its journey through the various machines which it passes until at last it is bottled and capped, it comes into contact with numerous employees and anyone of them, if diseased or a carrier, may infect it. That the possibility of milk being infected after its arrival in the city is not fanciful is shown by the experience of Rockford, Ill., in 1913, where the milk of no less than three different contractors was received pure from the farmers but in various ways was infected before delivery to the public. As an instance of infection of the milk in transferring it from the cans in which it arrives to others may be cited the Somerville epidemic of 1892. The milk was brought in the shipping cans to the milk plant where it was mixed in a large tank and drawn off through faucets at the bottom into smaller cans for delivery to the trade. One of two brothers who attended to the work in the dairy had walking typhoid fever; consequently there resulted 30 cases of typhoid fever among the customers.

**Infection of Milk by Cans and Bottles.**—One of the serious problems of infection that both producers and retailers have to meet is that which arises from the steady flow of cans and bottles to the public and back again. Some of them get into shops and homes where there is contagion or are handled by carriers at some stage of the journey. Consequently they come back to the farm or milk plant in an infected condition and communicate disease to those that handle them or to customers if they are sent out again without thorough sterilization. Likewise bottles and cans may be infected at the milk plant or farm by being filled with milk from cows suffering with disease communicable to man so that if these cans are picked up by dairymen and used without sterilization the milk from their own healthy herds may become infected and distribute the disease. As an instance of this sort, the infection with septic sore throat, of the routes of several of the dairymen of Batavia, Ill., through the use of the bottles of Dairy X may be cited. Can and

bottle epidemics are not rare by any means. What the danger from this source is should be clearly understood. Not every can or bottle that goes into premises harboring contagion is infected. In fact probably but few of them are and those are the ones with which the victim of the disease or perhaps his attendants come into direct or indirect contact; the others escape infection. Perhaps the likelihood of infection is greatest where the patient is coming down with the disease or is convalescing for in these stages he is about and helping himself. However, if bottles are handled by the patient's nurse or are carried into the sickroom there is danger throughout the illness. There are but two safe courses for the milkman to pursue. The better is to insist on leaving no bottles during the illness but instead to pour the milk into a covered container furnished by the householder. The other way is to leave bottles as usual but to carry none away till the sickness is over and then to make a special trip for them and disinfect them thoroughly by themselves. The objections to this way of doing are twofold, namely: (1) that many bottles accumulate at the residence, to the annoyance of the householder, and to the cost of the dairyman; and (2) that there is some danger in returning infected bottles to the dairy. The board of health of Montclair, N. J., has met the danger of infected bottles in a commendable way by informing the dairymen concerned, of the presence of contagion as soon as the board itself is notified by the attending physician of the case. It is recognized that this mitigates the evil rather than prevents it for in the prodromal stage, while the case is under observation by the physician it may be infectious and do damage. However, this notification protects both dairymen and the public to a considerable extent, and it is to be regretted that it has not been generally adopted.

As an example of an epidemic caused by infected cans that at Savannah, Ga., in 1907, will suffice. Sixty-three of the 95 cases appeared on the route of a wholesaler who supplied, among others, a depot that was located in a bake shop over which there was a case of typhoid fever. The cans were returned unsterilized and so used, to supply other customers.

Of late years many epidemics have been traced to the use of infected bottles. In Montclair, N. J., in 1901, cases of diphtheria suddenly appeared on one of the most prominent dairy routes of the town. Cultures were taken from the throats of the entire dairy crew and two of them proved positive. The crew was isolated and delivery of the milk suspended for 3 days. New cases ceased to appear within 2 days after the dairy was closed. In all there were 57 cases, 22 in Montclair and 35 in neighboring towns. The crew remained isolated for 3 weeks during which period virulent bacilli were found at one time or another in the throats of 17 of the men. At no time were any of the men ill or did they exhibit clinical symptoms other than a reddening of the throats of the

two men that were first picked out. It seems that it was the custom of the dairy to leave bottles at homes during the course of contagious diseases and at the removal of quarantine to carry them back to the dairy and sterilize them before using them. In winter the breakage was considerable and so to avoid this loss the bottles were kept in a safe place till the advent of warm weather when the whole batch was sterilized at once. It transpired that about 1 week prior to the appearance of the first case of diphtheria in Montclair the two men who were first removed from the crew were sent down to a shanty to boil out the winter's stock of infected bottles. They finished the job, returned to their quarters and were milking as usual that evening; so the explanation of the outbreak is manifest.

In December, 1902, in Montclair, N. J., the author investigated a typhoid fever outbreak that appeared on the route of a dairyman whose brother produced the bulk of the suspected milk but who also handled a small amount that he purchased from a wholesaler whose supply came from 10 different farms. Searching investigation at all of the 11 farms under suspicion failed to reveal any cases of typhoid fever thereon or that any employees had quit them for any reason. The dairyman volunteered the information that he believed that it was the wholesaler's milk that was infected for the disease was wholly confined to this pint-bottle customers for which trade the wholesaler's milk was solely used, the quart-bottle customers being entirely supplied from his brothers farm. This led to a close reëxamination of the wholesaler's business but no apparent cause of infection was discovered nor were there any cases of typhoid fever found on a retail route run by the wholesaler in Newark, whereas inquiry in Bloomfield showed that the dairyman had cases on his delivery route there. These facts, coupled with the admission on the part of the dairyman that he had not sterilized his bottles thoroughly, led to the conclusion that the epidemic was caused by infected bottles and to the withdrawal of the supply from town. The outbreak which at the time was on the increase stopped within 2 weeks thereafter. The reason why not a single quart-bottle customer in either of the two affected towns developed the disease was a mystery. It was ultimately solved by the discovery that a case of typhoid fever had come to Montclair from New York City and pending removal to the local hospital had remained in a household where the dairyman daily left and took away three pint bottles. The bottles that were removed were not sterilized but merely washed out, filled and served to other families. Had the case been reported to the board of health as the law required or had the dairyman faithfully sterilized the bottles the epidemic never would have occurred.

**Infection of Milk in Delivery.**—Milk may be infected on the delivery route. At Clifton, a suburb of Cincinnati, Ohio, in 1906, the milk of a

small dairy was delivered by a boy who had a "sore throat" but who was not under a physician's care. Thirty-six cases of diphtheria appeared on the route. Many incidents of epidemiological significance pointed to the milk and the boy as the source of infection. In Vermont, in 1902, six cases of diphtheria appeared on the route of a dairy whose milk was delivered by dipping from a large can by a boy who had "sore throat" but from which diphtheria bacilli were later isolated. Cases developed in houses where he left the milk but in others on the same street where he did not, there were none. In Chester, Mass., nine cases of typhoid fever appeared on the route of a dairy of which the wagon driver had just recovered from the disease, the epidemic stopped on his dismissal.

**Infection of Milk after Delivery.**—Milk may also be infected in shops where it is kept for sale; this is especially likely to occur if it is dispensed from cans or diptanks. At Hamar, Norway, in 1900, there were 42 cases of typhoid fever among the customers of a shop where the proprietor and his wife had the disease; the latter tended store while still ill. Savage records an outbreak of scarlet fever reported by Robertson in 1901. Forty cases were traced to a milk shop that communicated by a short passage with a house wherein was a woman suffering from an unrecognized case of scarlet fever. On the removal of the woman to a hospital the epidemic waned.

Milk is sometimes infected after delivery in homes, restaurants and hotels. In private homes the infection is most likely to occur when there is contagion in the household but at other times it may be brought about by servants and others who are carriers. In any event the cases are usually restricted to the members of the family and to friends. From milk infection in restaurants and hotels widespread infection may result. The sudden appearance in Boston, Mass., of 37 cases of typhoid fever about Sept. 21, 1909, led to the inquiry into conditions at a hotel in Jefferson, Mass., because all of the patients told of having spent Labor Day, Sept. 6, there. After some investigation interest centered on a waitress who in a very tired condition, left the hotel Sept. 9, and who called a physician on the 15th. She gave a positive Widal reaction on the 22nd, which showed that her case antedated the cases among the guests by 1 or 2 weeks. The bulk of the milk used at the hotel arrived at 8 a.m. part being used at once and part being kept over night and served the next morning. When the hotel was crowded the capacity of the ice chest was overtaxed and consequently the milk was insufficiently refrigerated. The milk was ladled out of the cans into pitchers by maids, who filled the glasses from them; often the dippers dropped back into the cans. The waitress who was ill was fond of milk and often made her supper of milk and cakes, helping herself from the cans. It is believed that on Labor Day eve she infected the milk and as it was not properly iced at that time there was an abundant growth of typhoid germs in the

milk next morning. In all there were 59 cases in 52 households that were located in 10 different cities and every one of the patients is known to have used the milk.

**Impossibility of Protecting the Milk from Infection.**—The recital of these specific instances of milk infection makes it obvious that no producer or purveyor of raw milk can be absolutely certain that the article that he is marketing is free from contagion. Pestilence in invisible form and devious ways sneaks into the dairy so unobtrusively that even the most careful and observant are unaware that anything is wrong till the blow falls. There exist three types of cases, or stages of communicable disease that may at any time bring infection into the dairy, and which it is impossible to guard against.

First are cases in the prodromal stage particularly of typhoid fever where germs are thrown off from the body before the victim feels the warning pains of illness.

Second are the ambulatory cases where the sick continue at their usual occupation, though feeling excessively tired, mean or distressed. These cases are apt to do a great deal of harm for they may distribute the virus of their disease for a considerable period and in many places before they are discovered. Indeed, some never are found out and these constitute the "missed" cases which are decidedly to be reckoned with in preventive medicine. The epidemic of scarlet fever that occurred in Boston, Mass., in 1910, was attributed to a missed case on some one of the 250 farms that supplied the dealer involved. There were 842 cases in Boston and its suburbs. Of 409 cases in the city proper 286, or approximately 70 per cent., were on the route of this one dealer. It was on April 25, that the milk was suspected and on that date orders were given to pasteurize it and sterilize the utensils. On April 27, pasteurization was begun, on the 29th reported cases reached a maximum of 123 reported new cases. Thereafter the epidemic declined and died out on May 7.

Third are the carrier cases. There are the acute carriers, persons that have convalesced but still give off the germs of the disease that affected them. In 1901, in Beverly, Salem and Bakers Island, there occurred suddenly 60 cases of scarlet fever among the customers of a single dealer. The trouble was traced to one of the farms whence his supply came, whereon a convalescent milker had infected the milk. Chronic carriers present a more serious problem. They are those that have been ill of infection made an apparently complete recovery but for months or years thereafter continue to scatter the specific germs of their malady. It is estimated that about 2 per cent. of all typhoid fever patients continue to discharge the bacilli in the feces and urine for an indefinite period after recovery. Of the many instances that might be cited to illustrate the infection of a milk supply by a chronic carrier, one

that was discovered by Boldman and Noble will suffice. In August, 1909, there was an outbreak of typhoid fever in that part of New York City that lies north of 40th Street. There were 380 cases above the normal for the district and a certain milk supply that was common to all was shut off. The infected milk was found to come from Camden, N. J., where it was found there had been a case of typhoid fever on a farm that was not a patron of the creamery that shipped the milk under suspicion. Inquiry developed the fact that every year there were in town 14 or 15 cases of "Camden fever" which was in reality typhoid fever. This is at the rate of 50 or 60 cases per 10,000 of population; an excellent illustration of the well-known fact that a few cases in a small town may be the equivalent of many in a metropolitan center. At the dairy where the typhoid fever was, it was found that the owner had the disease in 1864, and that in his family since that time there had been four cases of typhoid fever and three of "slow fever" resembling typhoid. On examination of the stools of the entire family it was found that those of the dairyman himself who had the disease 46 years before yielded typhoid bacilli in practically pure cultures on the medium in which platings were made. Connection of this man with the New York epidemic was established when it was found out that he ran one of the three local milk routes in Camden and was in the habit of turning over his surplus milk to his son-in-law who added it to his own and delivered it to the creamery of which he was a patron. "Thus the prevalence of 'Camden fever' in Camden and typhoid fever in New York were both explained." With the shutting off of the infected milk typhoid fever in New York City returned to normal.

The infection of milk by temporary bacillus carriers is perhaps most often accomplished by those harboring diphtheria germs. It is estimated that 1 per cent. of the urban population carries diphtheria-like organisms. The nurses of diptheria patients are particularly prone to become temporary carriers. The men in Montclair whose throats probably became infected with diphtheria germs while they were sterilizing the bottles afford a good example of a temporary carrier infecting a milk supply. There are also acute carriers those who having had contagious disease continue to carry the germs for a brief period. Such persons may also infect the milk supply.

**Characteristics of Milk-borne Epidemics.**—Milk-borne epidemics possess certain characteristics which should be remembered whenever it is sought to determine the source of an outbreak of contagion of unknown origin. There are two sorts of milk-engendered epidemics; those which burst on a community with explosive violence, and those which smolder on without exciting comment. Of the former type the epidemic of typhoid fever at Stamford, Conn., in 1895, is an example. There were 386 cases and 22 deaths in the period from April 15 to May 28. No less than 176 persons were stricken in the first week. Such

outbreaks rouse the community to instant action and something usually is done which checks the outbreak when it is on a rising tide. As an instance of the other kind of epidemic that at Belleville, Ill., may be cited. In the 7 months from July, 1911, to January, 1912, there were 23 cases of typhoid fever which if the same distribution of cases had continued throughout the year would have been equivalent to a typhoid morbidity rate of practically 14 per 10,000 of population and which is not excessive. As a matter of fact the cases being distributed in the practice of several physicians and among people who as a whole were unacquainted with each other attracted absolutely no attention but when 24 cases appeared in February and 41 in March bringing the rate up to nearly 56 there was alarm at once. It was found that over 85 per cent. of all the cases were due to the milk of a single dairy which all this time had been kept infected by a carrier who only at irregular intervals came into contact with the milk supply and infected it. The increased number of cases in February and March was in part explainable by the fact that during these months the contact of the carrier with the route was more regular. Had typhoid fever been a reportable disease in Illinois at that time suspicion would probably have fallen on the dairy in question sooner. Hill tells of the experience of North Branch, Minn., where one of the physicians pointed out that in his 17 years of practice during the first 12 there was no typhoid fever but that in the last 5, native cases of unknown origin had not been infrequent. Acting on this information a list of 21 cases of typhoid fever that had appeared in the town in the last 5 years was made and inquiry showed that 17 of the patients were regular customers of a dairyman who had come to town 5 years before, besides which, two were occasional customers and two more might have been. It developed that the wife of the dairyman who had typhoid fever 22 years before washed the cans. This woman showed a positive Widal reaction but typhoid bacilli were not isolated from her stools. She was forbidden to have anything to do with the dairy and the proprietor was told that if another primary case of typhoid fever appeared among his customers the dairy would be closed up. Rumors of this were hinted about the town so that trade fell off and the family moved away, after which there was no more typhoid fever. Thus all the cases of typhoid fever in North Branch were due to the occasional infection of the milk supply.

The explosive sort of epidemic is usually thought of as being typical of milk-borne outbreaks, but the smoldering kind must be very common especially in communities that lack a modern health department and laws compelling compulsory notification of contagious disease. No doubt too, much of the sporadic and residual typhoid that persists in our large cities, were all the facts known, might be traced to occasional or intermittent infection of the food supply by carriers and others.

Milk-borne epidemics follow the delivery wagon. This is most plainly seen in small routes supplied from a very few farms; in large routes where all the milk is not mixed together the connection between milk delivery and contagion may be less obvious, but usually patient inquiry at the dairy and along the route will develop such a relationship if it actually exists.

Great care must be taken not to unjustly impute an epidemic to a milk supply. The mere fact that the number of cases is large, while sufficient to arouse suspicion, does not warrant the conclusion that the supply is actually responsible for an outbreak. The percentage that the milk served by the suspected dairy forms of all milk in the district under scrutiny must be determined, as well as the number of cases on the route. A dairyman who serves 50 per cent. of the families in a district may be expected to have among his customers a large number of cases of a contagion that breaks out therein. Harrington instances an outbreak of scarlet fever in Boston in 1897 that was wrongfully attributed by the public to a milk dealer who delivered to most of the stricken families. Careful investigation by the health department showed that the first case was that of a child who did not have the accused milk and that the epidemic was spread by contact from this first case. Pease tells of an epidemic where 50 per cent. of the cases were customers of a single milk dealer who was forthwith accused of causing the outbreak but who was cleared of responsibility, upon it being shown that an infected water supply was really to blame, it being simply a coincidence that the dealer supplied 50 per cent. of the cases.

In milk-borne epidemics it so often happens that more than one case appears at the same time in a single household that such occurrences warrant the suspicion that the milk supply may be involved.

It frequently happens also, that the better-class houses are invaded for the reason that the occupants can best afford milk and so use it more freely than do the poorer classes. Those households using the most milk are most frequently attacked and show the greatest percentage of cases.

Likewise, there is a special incidence among milk drinkers; often a member of a household who abhors milk will escape infection, whereas those that drink milk freely are attacked.

The age and sex of the victims is frequently indicative that milk is responsible for an outbreak. If the sufferers are mostly women, young people and children, the epidemic is likely to prove to be milk-borne, for they consume milk more freely than adult males. Judgment must be exercised in applying this rule, for in some communities children form a considerable part of the population while in others they are conspicuously absent.

As to the character of milk-borne outbreaks there is some evidence to indicate that the infections may be more benign than when they origi-

nate from direct contact or in other ways. Savage says that in some epidemics of scarlet fever spread by milk that a number of cases have shown so few symptoms of the disease that apart from their relationship to other and undoubted cases a certain diagnosis of scarlet fever would not be possible, and quotes Newsholme on the scarlet fever epidemic at Brighton, England, in 1902 and Buchanan on the outbreak at Kensington, England, in 1875. He points out that in the acute infectious diseases the smallest percentage invasion of households is met with in scarlet fever outbreaks and says that it would probably be higher if the atypical cases, mainly or exclusively with symptoms of sore throat, were included. Savage also thinks contact cases less frequent in milk-borne outbreaks than in those having other origins.

Touching milk-borne typhoid fever, Newman says that the incubation period is shortened, attacks are often mild, contact infectivity reduced and the mortality rate lower than usual.

**Injury Done by Milk-borne Epidemics.**—The damage done by the contagion that is spread by milk cannot be accurately gaged. The amount of milk that becomes infected as compared with that produced is very small and were it to be considered in that light only could be disregarded but every epidemic stands for a definite amount of human misery and loss which added to that sustained in epidemics that have gone before makes a sum that compels attention. Boston, Mass., despite the fact it has a very fair milk supply, has had the following record of milk-borne contagion:

| | Cases |
|---|---|
| 1907, diphtheria | 72 |
| 1907, scarlet fever | 717 |
| 1908, typhoid fever | 400 |
| 1910, scarlet fever | 842 |
| 1911, septic sore throat | 2,064 |
| | 4,095 |

Such a series of epidemics is unusual but in almost every community where raw milk is bought and sold something of the kind is going on, so that the situation should be frankly faced and dealt with, without either minimizing the danger or exaggerating it.

The loss that contagion causes is felt all along the line from the consumer's home to the farm. To begin with there is the anguish of the stricken family and the sufferings of the victims. A 10 days' illness is succeeded by longer convalescence during which time bills for medicines, the nurse and the doctor accumulate, and if death ensues the expenses of the funeral are added. If the wage-earner contracts the disease his earning power for the time being is gone. So that advent of contagion in a home is serious and may even bring a family from a self-sustaining condition to a dependent one. The retailer is likely to suffer

severe loss from an epidemic. At the first rumors of trouble of this kind customers turn to other dealers and there consequently results a contraction in business that is more or less permanent, depending somewhat on the quality of the milk that has been delivered by the dealer and on his standing with his trade. Most retailers have contracts with farmers that hold for some months for the delivery of a certain amount of milk daily. So, when shrinkage in the trade takes place, the milk keeps coming regardless of the fact that there is no market for it. Therefore, it has to be manufactured into butter or cheese usually with attendant loss. If the milk is infected on the farm the supply is usually shut off at once which is likely to mean severe contraction of the retailer's supply and complete loss to the farmer, although some contractors deem it good policy to pay something for the milk.

**Control of Milk-borne Diseases.**—In the United States responsibility for the control of contagious disease is placed on the local or on the State health department. Something can be accomplished by inspections of the premises whereon the milk is produced or sold. Polluted water supplies can be eliminated; insanitary privies cleaned up; screening against flies can be encouraged and wholesome conditions of living can be fostered. Where milk is sold in stores the same sort of measures should be applied and in addition the sale of milk from rooms that are in part occupied by the family should be forbidden.

Departmental records should be kept in such a way as to show the relation of milk supplies to communicable disease; the thing vital to the success of doing this, is to get all cases promptly reported. When this is done and the cases marked up on the dairy routes which the victims patronize it is often possible to detect an epidemic at its inception and to institute measures to check it. As has been already said some help is given by a system of notification warning dairymen of the appearance of contagion in the household.

However, all such measures are only helpful in reducing the opportunities of infection. Once, it was hoped that by thorough inspection of dairies, strict quarantine and similar measures to reduce danger of infection of milk supplies to an all but negligible minimum but better knowledge of the modes of transmission of contagion, of carriers, missed cases, bottle infections, etc., have shown that it is a delusion to cherish such a hope. In its place has been substituted faith in pasteurization by the "holder" process. It has been proven that the germs of disease in milk are killed by an exposure of 140°F. for ½ hr. so that if the process is properly protected by thorough inspection, the safety of the milk can be guaranteed.

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## CHAPTER III

# DAIRY CATTLE AND THE DAIRY FARM

**Origin of Domesticated Cattle.**—The dairy industry of the United States is immensely important. A vast amount of capital is invested therein; to it the choicest of agricultural lands are devoted and from it an army of men get employment, but the gains that it offers are not easy. To reap them requires training and skill of a high order backed by experience. The questions that assail the dairy farmer are many; they begin with the cow herself.

The origin of domesticated cattle has not been certainly determined but two wild species namely *Bos primigenius* and *Bos longifrons* seem to have been particularly important in their evolution. The former is known to us by old paintings that are believed to represent the animal and by skeletons. It persisted until the early part of the seventeenth century in the regions of the upper Duna and Dnieper Rivers and in the Carpathian Mountains. It was 6 to 7 ft. at the withers and 10 to 12 ft. long and was characterized by a long narrow head.

*Bos longifrons* is believed to be derived from Asiatic species, probably *Bos sondaicus.* It seems to be identical with the marsh cow of the Lake Dwellers and its earliest and most typical forms are found on the northern shores of the Mediterranean, the Alpine region and the Atlantic coast of western Europe. It was smaller than *Bos primigenius* with shorter horns, face and forehead.

Keller derives the European cattle from two distinct races, thus:

1. Those of *Bos primigenius* ancestry. They are characterized by a long narrow head and include the English Park cattle, the North German, Lowland, Dutch, Steppe, Simmenthal and Freiburg spotted breeds.

2. Those of *Bos sondaicus* ancestry. They are characterized by a broad short head and include the Albanian, Polish, Hornless Fjell and Brown Swiss breeds as well as the Channel Island and English cattle except the Longhorn and Scotch Highland, but the Shorthorn, Ayrshire and some others, early received an admixture of *Bos primigenius* blood.

**Introduction of Cattle into America.**—Cattle are not native to America. The first were brought over by Columbus on his second voyage in 1493. Later, settlers from Spain brought cattle to the West India Islands whence they were carried to the mainland both north and south of the Isthmus of Panama. In 1525 cattle were carried to Vera Cruz

where they multiplied and gave rise to the stock later known to breeders in the United States as "Texas" cattle. Cattle were brought to New-Foundland and Nova Scotia in 1553 and are said to have been introduced to Sable Island as early as 1508. Importations to Canada were largely from France, particularly from Normandy and Brittany. Many cattle were carried to Jamestown, Va. from the West Indies in 1610–11 and English breeds were also introduced there. In 1624, the first cattle came into Massachusetts Bay. Boston imported mostly English breeds, the Devon predominating. Plymouth brought in cattle from both England and Holland. In 1624, the Dutch settled New Jersey and in 1627, the Swedes, Delaware; both colonists brought cattle with them. In 1631–32–33 Captain John Mason imported a large yellow breed of cattle from Denmark into New Hampshire. In New York the cattle were largely of Dutch origin and in Pennsylvania they were brought in by Dutch and Swedish settlers. Although breeds were established at this time in Europe it is doubtful if many of the cattle imported by the colonists were purebreds; most of them were nondescript and from these divers stocks originated the so-called "native" cow of America.

Probably the Devon cattle that were brought into New England were among the first purebred cattle to arrive in this country as were the Shorthorns imported to Virginia by Miller in 1783.

As a rule the cattle of the United States have come from the British Isles, the only important exceptions being the cattle of Holland and the Brown Swiss.

Since cattle were not native to America there are no strictly American breeds, but American breeders have produced strains such as the Gore breed and the American Holderness that have attained considerable prominence but except for the Polled Durham and the French-Canadian none has obtained a national reputation.

**The Dairy Type.**—Since there is a direct relation between the ability of a cow to produce milk and butterfat profitably, and her conformation and nervous constitution, dairymen seek animals of the dairy type. A good dairy cow must have, in addition to her ability to assimilate the food necessary to repair tissue waste and keep her organs in a healthy functioning condition, an inherited tendency to manufacture milk from her provender. This predisposition is spoken of as dairy temperament and is correlated with good health, a strong constitution, large feeding ability and capacious milk organs. Good health is indicated by the carriage of the animal, by mellowness of the hide and by slickness of the hair.

A strong constitution is a matter of inheritance and good care and is important, for a cow must be strong and vigorous to make milk not only for 10 or 11 months but for years.

Since within the chest are contained the vital organs, large chest

capacity is supposed to show strength of constitution. Large feeding capacity is essential, for whatever may be the inclination to produce, it cannot be successful unless the barrel is of sufficient size to handle large amounts of the bulky foods The barrel should be long between the heart girth and hips, and should be broad and deep, with wide well-sprung ribs, far apart. Good teeth and a broad muzzle are important.

The milk organs are the udder, teats, milk veins, and milk wells. The udder must be large and must have quality. It should be broad and long rather than deep and the fore udder should be well developed. Fat and fleshy udders are undesirable, for those distended with such tissue, even though they may be of large size, may have less capacity than smaller ones of better quality. The teats should be of convenient size and placed at the four corners of the udder. Since milk is manufactured from the blood the size and development of the milk veins which carry it from the udder are regarded as important, and large, crooked, much-branched veins are considered an indication of good milking capacity. However, more importance may have been attached to the milk veins than is warranted. Dr. King of Maine pointed out that their external appearance does not indicate their blood-carrying capacity for the walls may be thick and the lumen small and furthermore, that in some animals the blood flows more rapidly, than in others. Graves of the Oregon Experimental Station tied off the milk veins of a cow so that no blood could pass through those that are ordinarily seen extending forward from the udder and found that there were produced, neither ill effects on the cow nor decrease in her milk flow. Careful investigation is needed to determine the importance of these observations. The milk veins enter the wall of the belly through holes known as milk wells and their number and size is considered indicative of the amount of blood it is possible to carry back into the body from the udder.

A cow must have a well-developed nervous system to direct and regulate milk secretion, digestion and other functions, but the nerves must be under control and the disposition quiet, for her to rank well, as a dairy animal. Large milk production seems to be closely associated with abundant nervous force.

A proper nervous temperament is denoted by prominent bright eyes, broad forehead and a prominent loose-jointed backbone. The nerves branch off from the spinal cord between the vertebræ, hence the larger the nerves the more open the vertebræ and the wider apart the ribs.

In appearance a good dairy cow must show quality in bone, hair and hide and must have large capacity in the rear where the food is digested and milk secreted. A good dairy cow does not usually carry flesh long after freshening; therefore the hips and shoulders are angular, the backbone prominent and the ribs plainly seen.

Crandall points out that:

"Some breeders have selected on type alone and thereby have produced animals that to the fanciers, satisfaction fulfil the requirements of the breed score cards as to the finer details of physical conformation but that are not noted for their producing ability. Other breeders relying less on the breed score card and on show ring judgment have, while paying due regard to physical fitness and the breed characteristics, made the actual measured producing ability of the individual and of its near ancestors the dominating factor in selection and so without sacrificing those characteristics of color and milk quality which indicate purity of blood, have improved the producing abilities of their herds. Thus, in the higher producers of the four principal dairy breeds, has been developed a similarity of type, characterized by good dairy temperament or ability to produce milk, large feeding capacity, strong constitution and capacious milking organs. That continual selection and development for production has evolved a type common to all breeds is convincing evidence that such a type is best adapted for high production. It follows, that when it is desired to distinguish profitable from unprofitable cows judgment may be based upon a simple standard or score card considering physical requirements which are logically and physiologically related to the organic functions necessary to milk production. These functions are those of the vital organs to furnish pure blood to the body and secretory glands, of the digestive organs to digest large amounts of food and to make available material for use in the body processes and in milk secretion, of the milking organs to secrete large quantities of milk from the blood coming to them, of the generative organs to produce strong offspring and of the nervous system to stimulate and to coördinate the activities of all organs and glands in the efficient production of milk. A weakness in any one of these functions weakens the production of the animal. That a judge must weigh the varying degrees of excellence in the combinations of these functions occurring in different animals, explains the impossibility of his accurately estimating, producing ability.

"There are qualities of form, capacity and material in certain body parts and their combination which indicates their adaption and capacity for milk production. A standard which considers these combinations of parts directly in their relation to function emphasizes that function and considers the physical parts only as a means in estimating the ability of that function to perform. The user of such a standard thinks and judges in terms of function, and not of parts.

"The following score card in use at the University of Illinois is made up with the above requirements in mind. After practice in its use, few students fail to distinguish the better of two cows when the difference in their yearly production is 4,000 lb. of milk or more and many students succeed in selecting the better animal when the difference between the two is only 2,000 in a yearly production of 10,000 lb. or more."

The cow of modern herds is not only a splendid example of man's conquest of nature by domestication of wild animals but is a triumph of the breeder's art. The animals have been plastic in his hands and have been moulded to man's needs until they have been developed to such a degree that they may be regarded as highly perfected machines for efficiently producing food. Breeders have developed three types of animals, beef cattle, especially adapted for meat production, dairy cattle,

specialized for milk production and general or dual-purpose cattle, which are supposed to be fitted to the needs of the general farmer and are claimed to be good for both milk and beef production.

University of Illinois—Dairy Cow Score Card

**Scale of Points—Cow**

| | | Possible score |
|---|---|---|
| Indicating dairy tendency or temperament 30 | WEIGHT—Estimated—pounds; actual—pounds | |
| | FORM—Parts well balanced; tendency to triple wedge shape as viewed from front, top, and side | 6 |
| | Shoulders, withers, hip, and pin bones angular and free from fleshiness, (period of lactation to be considered) | 2 |
| | Thighs incurving, thin, wide apart | 2 |
| | Open conformation in withers, shoulders, and backbone | 3 |
| | QUALITY—Bone, medium as indicated by clean face and legs and long, slim tail | 3 |
| | Hide free from fleshiness | 2 |
| | NERVOUS DEVELOPMENT—Face broad between eyes, dished; eye prominent, clear, quiet | 3 |
| | Backbone large and prominent | 2 |
| | Disposition active, with good nerve control | 3 |
| | BREED CHARACTER—Size and color, indicating a high percentage of the blood of some one dairy breed | 4 |
| Indicating constitution and general health 16 | CHEST—Deep and full, showing lung capacity; wide on floor and full at elbows | 10 |
| | CONDITION—Thrifty and vigorous; skin mellow, loose, not papery or hard; hair fine and soft, not wiry | 6 |
| Indicating feeding capacity 24 | BARREL—Long; ribs broad, wide apart, loin long | 10 |
| | Wide; ribs well sprung, loin broad | 4 |
| | Deep; ribs long | 6 |
| | MUZZLE—Wide, full lips; strong jaws, good teeth | 4 |
| Indicating development of maternal function 30 | UDDER—Capacity; large in size and of good quality | 12 |
| | Shape; attached high and wide at back; extending well forward; quarters evenly developed | 6 |
| | TEATS—Uniform; of convenient size and length; free from lumps and warts, extra orifices and leakage | 4 |
| | MILK VEINS—Large, tortuous, and much branched; milk wells large | 4 |
| | RUMP—Broad at both hips and pin bones; level; indicative of pelvic capacity | 4 |
| | TOTAL | 100 |

In the United States the strictly dairy breeds of cattle, among which the most prominent are the Holstein, Ayrshire, Brown Swiss, Guernsey and Jersey, are the dominant animals and are forcing their way into all districts that are important sources of city milk supply. They are the answer of those breeders who have given milk production special thought to the question of milk supply, for their inherited tendency to make milk adapts them to cope with the problem.

**Holstein-Friesian.**—The Holstein-Friesian is one of the largest breeds of cattle. A reasonable and moderate weight for an aged bull is from 1,900 to 2,000 lb. and for cows is from 1,250 to 1,400 lb. The calves at birth average 90 lb. in weight. In America the animals are almost always black and white displayed in patches; in the Netherlands several purebred herds of red and white animals exist. There is some evidence to show that red was the original color and that the black was acquired from Jutland cattle in the latter part of the 18th century. In shape the animals have a long head, dark or flesh-colored muzzle, and large long bodies, with well-sprung ribs denoting great feeding capacity. The hips are often prominent and the rump long and level. The udder is large and U-shaped with big teats placed at the corners. The cows are copious milk producers; fair specimens should yield from 7,000 to 9,000 lb. of milk a year and many records far surpass this. The milk is chalky white and averages about 3.5 per cent. butterfat but varies within wide limits, some animals producing milk of lower test than the legal standard required by many of the States while others test above the average. As a butterfat producer the breed takes high rank because of the big milk yield. The fat globules are small and do not rise as rapidly nor separate by gravity as perfectly from the milk serum as do the globules of the Jersey and Guernsey breeds; consequently the cream line is not so well defined.

TABLE 31.—HOLSTEIN—FRIESIAN RECORDS

| Cow | Pounds of milk | Pounds of butterfat | Average per cent. of butterfat |
|---|---|---|---|
| Tilly Alcarta | 30,452 | 951 | 3.13 |
| Creamelle Vale | 29,591 | 925 | 3.12 |
| Finderne Pride Johanna Rue | 28,404 | 1,176 | 4.14 |
| Dutchess Skylark Ormsby | 27,761 | 1,205 | 4.34 |
| Cioantha 4th's Johanna | 27,432 | 998 | 3.63 |
| Banostine Belle De Kol | 27,404 | 1,058 | 3.86 |
| Highlawn Hartog De Kol | 25,592 | 998 | 3.90 |
| Pontiac Clothilde De Kol | 25,318 | 1,017 | 4.01 |
| Finderne Holingen Fayne | 24,612 | 1,116 | 4.53 |
| Lindenwood Hope | 20,405 | 953 | 4.56 |

At the present time the breed is generally distributed over the United

*Courtesy of W. J. Fraser.*

FIG. 1*a*.—Holstein-Friesian bull, Sarcastic Lad.

*Courtesy of W. J. Fraser.*

FIG. 2.—Holstein-Friesian cow, Tina Clay Pieterje Bell.

States and is a favorite in sections where production of milk for city consumption is the chief industry because the cows give large quantities of good milk of low fat content that can be sold cheap at a profit. The Holstein-Friesians are good cows for patrons selling to creameries and cheese factories that purchase milk by bulk and not on the butterfat basis. Partizans of the breed claim that because of the low fat content of the milk and the small size of the fat globules the milk is especially adapted to infant feeding.

Admirers of other breeds contend that when the milks thereof are properly diluted they give results in infant feeding that are as satisfactory as those obtained with Holstein milk.

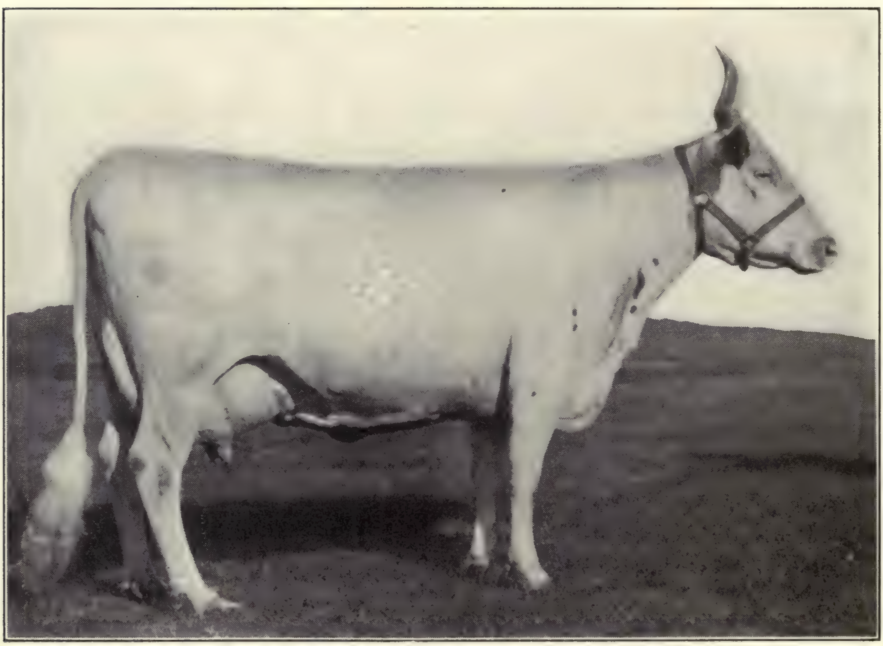
**Ayrshire.**—The Ayrshire originated in the county of Ayr in southern Scotland. The basal stock was the native cattle of the region but the breed seems to have been evolved by the crossing of many of the best milk-producing breeds. Several authorities instance the use of different cattle by various breeders in improving the breed. The Shorthorn, Dutch, Devon, Channel Island, West Highland and Hereford cattle all are mentioned as having been utilized in developing the Ayrshire. The original marking appears to have been black, but about 1780 red and white became fashionable, later brown and white mottled cattle were preferred and of recent years there has been a craze for white animals with a minimum of red or brown. Ayrshire bulls weigh from 1,400 to 2,000 and the cows average 1,000 lb. The bodies of the animals are capacious, the ribs long and well-sprung while the rump is usually high, broad and long. The uniform well-shaped udders are notable. They are not pendant but the forepart has unusual extension and the rear is carried well up behind. The teats are well-placed but are apt to be inconveniently small for milking. American breeders are endeavoring to overcome this defect.

Ayrshires were first brought to Canada between 1820 and 1830. The first animals to come into the United States are said to be some that were imported to Connecticut in 1822 but this is not certain, and many regard the Massachusetts importation of 1837 as the first. For a time thereafter importation continued but it dropped off only to be resumed actively in recent years.

The Ayrshire has always been known as a good milk producer; cows rated as fair specimens of the breed will give 7,500 lb. of milk a year. The milk is white and tests on the average of 3.8 per cent. butterfat. The fat globules are small and the total solids high. The milk has been called the perfect milk by admirers of the breed, partly because of the proportion of fat to solids-not-fat, and is especially recommended by many for infant feeding. For city milk supply the breed is satisfactory as the cows are consistent producers of milk that tests 12.5 per cent. total solids and a trifle under 4 per cent. butterfat. As butter cows, the Ayrshires

Courtesy of D. Whiting & Sons.

FIG. 3.—Ayrshire bull, King of Arludo.



Courtesy of the Ayshire Breeders Association.

FIG. 4.—Ayrshire cow, Garclaugh May Mischief.

have not been so successful as some other breeds. In Scotland, large quantities of cheddar cheese are made from the milk and for cheese making the milk is of the best because of its small fat globules and high protein content.

TABLE 32.—AYRSHIRE RECORDS

| Cow | Pounds of milk | Pounds of butterfat | Average per cent. of butterfat |
|---|---|---|---|
| Garclaugh May Mischief | 25,328 | 895 | 3.53 |
| Auchenbrain Brown Kate 4th | 23,022 | 917 | 3.99 |
| Lilly of Willowmoor | 22,596 | 955 | 4.23 |
| Garclaugh Spottie | 22,589 | 816 | 3.61 |
| Auchenbrain Yellow Kate 3d | 21,123 | 888 | 4.21 |
| Gerrantown Dora | 21,023 | 804 | 3.83 |
| Jean Armour | 20,174 | 774 | 3.84 |
| Rena Ross 2d | 18,849 | 713 | 3.79 |
| Nethehall Brownie 9th | 18,110 | 820 | 4.53 |
| Henderson's Dairy Queen | 17,974 | 738 | 4.10 |
| Agnes Wallace of Maple Grove | 17,657 | 821 | 4.65 |

**Brown Swiss.**—The Brown Swiss cattle were introduced to the United States from Switzerland which country is famed for this breed and also for the Simmenthal.

The Brown Swiss were first brought to the United States in 1869 when they were imported to Massachusetts from the Canton of Schwyz. Other importations followed till at the present time they are found in almost every State but not in large numbers. The semiofficial records of 18 cows in the herd of E. M. Barton of Hinsdale, Ill., gives an average of 9,448.8 lb. of milk and 363.7 lb. of butterfat per cow per year, making the average butterfat test 3.84 per cent. Of these cows seven produced over 10,000 lb. of milk a year apiece, the maximum being 11,274 lb. containing 391 lb. of butterfat. The maximum butterfat yield per cow was

TABLE 33.—BROWN SWISS RECORDS

| Cow | Pounds of milk | Pounds of butterfat | Average per cent. of butterfat |
|---|---|---|---|
| College Bravura 2d | 19,460 | 798 | 4.10 |
| Ethel B. | 18,816 | 780 | 4.14 |
| Lottie G. B. | 17,595 | 664 | 3.71 |
| Iola | 16,844 | 685 | 4.07 |
| Rosalind B. | 16,804 | 727 | 4.33 |
| Kaliste W. | 16,609 | 650 | 3.94 |
| Ola B. | 15,602 | 548 | 3.51 |
| My Own Baby | 15,769 | 628 | 3.14 |
| Merry Merney | 15,679 | 628 | 4.00 |
| Malitia May | 14,791 | 634 | 4.29 |

*Courtesy of E. M. Barton.*

FIG. 5.—Brown Swiss bull, Junker.

*Courtesy of E. M. Barton.*

FIG. 6.—Brown Swiss cow, Hirz.

455 lb. from 10,959 lb. of milk, making the average butterfat test for the period 4.15 per cent. In Switzerland the breed is frankly a dual purpose one but the breeders of the United States announce that the animals are to be developed here as a dairy breed. The color of the milk is about the same as that of the Shorthorn and seems well-suited for city milk supply. Some Brown Swiss records are given in Table 33.

**The Channel Islands Cattle.**—The Guernsey and Jersey cattle originated in the Channel Islands, a group that is partly made up of the islands of Alderney, Guernsey, Sark and Jersey and that is located in the English Channel directly south of England, from 4 to 40 miles off the coast of France. The origin of the breeds is somewhat obscure but they are supposed to have been derived from a cross of the cattle of Brittany and Normandy with cattle native to the islands. Formerly both in England and the United States the cattle of the Channel Islands were called Alderneys, a term that included both Guernseys and Jerseys. To protect their stock from cattle diseases and to maintain its purity the inhabitants of the Island of Jersey as early as 1763 passed laws prohibiting the importation of cattle from France; in 1789 the prohibition was extended to all cattle and there has been no importation since. A few years later the Island of Guernsey adopted the the same policy.

**Guernsey.**—The Guernsey is bred on the islands of Guernsey and Alderney where the intent is to secure uniformity of type and good producing animals. A mature bull should weigh about 1,500 lb. and a cow about 1,050. The animals are larger and of a less refined type than the Jerseys, are yellowish, brownish or reddish fawn, frequently with white markings on the legs and under part of the body. The muzzle is buff or flesh-colored and is surrounded by a whitish or yellowish circle of hair. The skin is mellow, thin, elastic and yellow, the horns and hoofs are amber-colored, and in the cows, the horns often curve gracefully over the face. The udder is large and the teats are of a good size.

The breed was apparently first introduced into this country from Alderney to Philadelphia in 1818. Importations from Guernsey came later and from 1830 to 1870 the animals were brought to Pennsylvania, Massachusetts, and other points along the Atlantic coast.

The cows rank high as milk producers, a yield of 5,000 lb. a year is easily averaged by a herd, and herds are reported averaging double this amount. The milk is very popular with consumers, because of its rich yellow color. The fat globules are large so that the milk creams easily and gives a sharply defined cream line.

As butter producers the cows have won special distinction. Owing to the natural yellow color of the fat globules, the butter has a beautiful golden hue that makes the addition of butter color superfluous. Some yearly records of milk and butterfat production are given in Table 34.

*Courtesy of the American Guernsey Cattle Club.*

FIG. 7.—Guernsey bull, Imp. Moss Raider.

*Courtesy of the American Guernsey Cattle Club.*

FIG. 8.—Guernsey cow, Murne Cowan.

TABLE 34.—GUERNSEY RECORDS

| Cow | Pounds of milk | Pounds of butterfat | Average per cent. of butterfat |
|---|---|---|---|
| Murne Cowan | 24,008 | 1,098 | 4.54 |
| May Rilma | 19,639 | 1,059 | 5.39 |
| Spotswood Daisy Pearl | 18,602 | 957 | 5.14 |
| Dolly Dimple | 18,459 | 907 | 4.91 |
| Imp. Daisy Moon 3d | 18,019 | 928 | 5.15 |
| Julie of the Chene | 17,661 | 953 | 5.39 |
| Dairy Maid of Pinehurst | 17,285 | 911 | 5.27 |
| Miranda of Mapleton | 16,630 | 927 | 5.51 |
| Yeksa Sunbeam | 14,921 | 857 | 5.74 |
| Imp. Beauty of Park Farm | 14,686 | 899 | 6.12 |

**Jersey.**—The Island of Jersey supports about 13,000 cattle. The Jerseys like the Guernseys are believed to be descended from the French cattle of Normandy and Brittany. It is probable that the cattle of the Channel Islands were at one time essentially alike and as the two breeds have been developed under practically identical climatic conditions the differentiation of the cattle is the result of the different ideals of the breeders in Guernsey and Jersey. While the Guernsey breeders were striving for uniformity of type and improved production, the Jersey breeders aimed at evolving an animal of refined type and perfect form. Both have been successful in developing breeds famed for high and economical fat production. In America, Jerseys have been very popular but American breeders have paid less attention to form and more to production than those of Jersey; consequently there are in America two types of animals, the small shapely ones, imported from the Island and the coarser plainer type produced here. In the show ring the standard of judging has been such as to establish the success of the imported animals while the records for production of the cattle of the American breeders has surpassed those of the Island type both in their native land and here. The future success of the breed in the United States as a practical dairy animal seems to depend on the wise development of the American type. As a persistent milk producer and as a family cow, the Jersey is unexcelled.

The animals are lean and graceful with the wedge shape markedly developed. They give the impression of having much capacity and power in a small body. In proportion to the size, the barrel is large and the ribs well-sprung. The udders are mellow, and milk out well, but not a few of the cows show a weak fore udder, though this is by means generally true, for others leave nothing to be desired in this respect. The head is rather short and broad between the eyes which are prominent; the face is slightly dished. The color of the animals runs from gray through fawn to a dark brown. Some excellent animals are brindled

*Courtesy of Hood's Farm.*

FIG. 9.—Jersey bull, Pogis 99th of Hood's Farm.

*Courtesy of Hood's Farm.*

FIG. 10.—Jersey cow, Lass 66th of Hood's Farm.

but they are looked upon with disfavor by those who place the tint of a cow above her performance at the pail. The Jerseys are graceful, active animals of nervous temperament which predicates intelligent handling, to get the best out of them. The breed is prepotent and the animals mature early.

The first definite importation of cattle to the United States from the Island of Jersey seems to have been that to Hartford, Conn., in 1850. After that, importations to Connecticut, Massachusetts, Maryland, New York, Pennsylvania and Canada became frequent. In importing from the Island, the blood of certain famous bulls has been most sought. This has resulted in the recognition of families of Jerseys in this country. The most famous is the St. Lambert which Eckles states originated in Canada and is descended from cattle imported by Stevens of Montreal and St. Clair of Vermont. The bulls Stoke Pogis and Stoke Pogis 3d are supposed to be predominant factors in the formation of the family.

As a rule Jerseys are not large milk producers but it is not unusual for cows to give 6,000 lb. of milk a year. The fat globules are large and yellow so that milk creams and churns easily and gives a sharply defined cream line. Being very rich it is very popular with those who can afford it. As butter producers Jerseys rank high. Some Jersey records are given in Table 35.

Table 35.—Jersey Records

| Cow | Pounds of milk | Pounds of butterfat | Average per cent. of butterfat |
|---|---|---|---|
| Eminent's Bess | 18,782 | 962 | 5.12 |
| Lass 40th of Hood's farm | 18,661 | 854 | 4.52 |
| Lass 66th of Hood's farm | 17,794 | 911 | 5.11 |
| Sophie 19th of Hood's farm | 17,557 | 999 | 5.69 |
| Jacoba Irene | 17,253 | 953 | 5.52 |
| Temisia's Owl's Rose | 17,055 | 863 | 5.06 |
| Spermfield Owl's Eva | 16,457 | 993 | 6.03 |
| Olga 4th's Pride | 16,275 | 851 | 5.22 |
| Olympia's Fern | 16,148 | 938 | 5.81 |
| Merry Maiden | 6,896 | 560 | 8.13 |

Other breeds of minor importance in the United States are the French Canadian, Dutch Belted and Kerry.

**French-Canadian.**—The French-Canadian cattle are interesting because they form the only successful distinctly dairy breed that has been developed in America. Grisdale says of them, that they are supposed to be derived from cattle imported from Normandy or Brittany by the French settlers of the 17th century; that many years of roughing it along with the people has made them hardy and that the process of

Courtesy of Dr. J. A. Couture.

FIG. 11.—French-Canadian bull, Fortune d'Or.

Courtesy of Dr. J. A. Couture.

FIG. 12.—French-Canadian cow, Filie.

selection which has evolved them has made them productive on light, poor rations. He says further that the French-Canadian cows are worthy of much consideration where a hardy breed of rustlers is required. The individual cow is somewhat small, weighing only 700 to 900 lb. A bull weighs about 1,000 lb. In general conformation they are somewhat rough and angular; in the cows the wedge shape is present. The color is black or dark brown. As milk producers they resemble the Jersey though in quantity and quality they fall somewhat behind that breed. An average of 6,500 lb. of milk of a little over 4 per cent. butterfat is about standard. The herd book dates from 1886 and is kept by the French Canadian Cattle Breeders Association.

**Dual-purpose Cattle.**—The dual-purpose cattle have been under sharp discussion for a long time. Their advocates claim that they combine the desirable features of both the beef and dairy types, the animals being economical milk producers and also valuable meat animals. The opponents of the type vigorously assert that there is no such thing as a dual-purpose animal, that the creatures either run toward beef production or toward milk production and in either case are only mediocre performers. At the present time the tendency among the shrewdest farmers is probably to rear either herds of beef or of dairy cattle; at the same time it is recognized that the dual-purpose animals are invaluable to a region that is passing from beef production into dairying. Herdsmen who have been used to the rough-and-ready ways of cattlemen find difficulty in turning to the care of heavy milk-producing cows for they need more careful and individual attention.

**Shorthorn.**—The Shorthorn is the dual-purpose animal that is of greatest importance in milk production. This breed originated in northeastern England in the counties of York, Durham and Northumberland and has spread over Great Britain and thence over the civilized world. Cattle of this type are believed to have existed previous to 1600. The first Shorthorns were imported to America in Virginia in 1783. The breed is one of the most popular in the United States. As a dairy animal the Shorthorn has had a larger influence in England, where it is a chief dairy cow, than anywhere else and much of the milk shipped to London comes from Shorthorn herds. In the United States, particularly in the central West, a considerable part of the milk supply is furnished by these animals. There are really two classes of Shorthorns; those that are unquestionably of the beef type and those of "milking strain" that make satisfactory dairy cows. Eckles says that in the United States Shorthorns have been developed almost exclusively for beef production and that consequently the typical purebred animal of this country has no claim to be regarded as a dairy animal but that there is a revival of interest in the milk-producing strain which of late has led to importation of animals of the dairy type.

Some American Shorthorn records which for the most part are those given by Eckles appear in Table 36.

TABLE 36.—AMERICAN SHORTHORN RECORDS (ECKLES)

| Cow | Pounds of milk | Pounds of butterfat | Per cent. of butterfat |
|---|---|---|---|
| Rose of Glenside | 18,075 | 625 | 3.46 |
| Mamie's Murriel | 16,201 | 575 | 3.49 |
| Lula | 12,341 | 515 | 4.17 |
| Panama Lady | 13,789 | 490 | 3.55 |
| Florence | 10,438 | 424 | 4.06 |
| College Moore | 9,896 | 407 | 4.11 |

The animals are commonly red, white or roan; cows of the dairy type weigh 1,200 to 1,350 lb. and at birth their calves weigh 70 to 90 lb. Their milk on test gives 3.6 to 4 per cent. butterfat and about 12.5 per cent. total solids.

**Choice of Breed.**—With these breeds to choose from the question naturally arises which is best, and to this query no definite answer can be given for the reason that each has its proper place and use and under intelligent encouragement will yield good results. As a rule the predilection of a dairyman for some one of the breeds is often a determining factor in choice, and rightly so, for a man is likely to succeed best with animals for which he has a peculiar interest and fondness. Broadly speaking it is generally wise to build the herd of animals that are common to the region in which the farm is situated, because the dairyman gains from the mutual interest of local breeders, the presence of fine specimens of the breed and the renown of the district as the home of many good cattle of a particular sort. Thus buyers from abroad seek out the place so that there is likely to be a ready market at good prices for surplus stock. Economic conditions have to be carefully considered; if the region is one where the cost of labor, or feed or the high price of land or high taxes put it at a disadvantage in competing with others in any branch of production this fact should be recognized and choice be made accordingly. If it is intended to sell milk to creameries or cheese factories that buy in bulk instead of on a butterfat basis or if milk is to be put out to a city milk trade that seeks only low price, the breeds that produce large quantities of milk will naturally be selected. On the other hand, if payment for milk is made on a butterfat basis or if it is intended to capture a city milk trade that will pay well for rich milk the breeds yielding milk testing high in butterfat will be picked out. Economy of milk production by the animals has to be taken into account. Cows that will produce the most milk or those making the most butterfat with the least consumption or cost of feed are sought.

It is best to have the herd composed of a single breed of cattle, but where heavy producing animals are used to supply milk to the public some keep a few cows of the breeds that test high in butterfat in order to hold the herd milk well above the legal requirements and to impart color to the milk as well as to help secure a sharp cream line.

**Importance of a Purebred Bull.**—Few farmers can afford purebred herds which would be serious were it not possible, by the use of a purebred bull, and by raising his heifer calves to breed up a grade herd that will compare favorably with and perhaps even surpass the production of a purebred herd. Progressive dairymen fully appreciate this and in many places maintain bull associations which enable the farmer of moderate means to secure service of the best animals. Normally a scrub bull depresses the milk and butterfat production of a herd and a purebred bull raises it but sometimes a purebred animal is a failure. The fitness of a bull to head a herd is judged by his conformation and the records of his female progenitors in milk and butterfat production. The test of his fitness is his ability to maintain the vigor of the herd and beget daughters with better records of milk and butterfat production than their dams.

**Importance of Testing Cows.**—A good judge of cattle, guided by his expert knowledge of type and form can pick out animals so shrewdly that the herd will contain but few poor ones. However, there are always those that do not work out according to form and the difference between the best performers and the worst is considerable. Indeed, between cows of the same breed there is likely to be as much variation as regards quantity and quality of milk production as there is between cows of different breeds. Moreover many dairymen lack the knowledge to enable them to select good milk-producing cows for their herds. Precise knowledge of the actual value of a cow as a producer of milk and butterfat can be obtained only by the use of scales and the Babcock butterfat tester. The milk of each cow should be weighed at every milking both because it gives the basis for rational feeding and because it measures the cows capability as a milk producer. The milk of each cow may be sampled at every milking and used to form a composite sample that is kept sweet by an added preservative and tested for butterfat at the end of a week, or samples may be taken and tested less frequently. From these tests and the amount of milk given by the cow her total butterfat production can be computed. So, it is possible to determine whether the cow is a profit maker or a star boarder. The importance of thus keeping tally on the cow's performance has been shown over and over again both abroad and in this country. Figures illustrative of what may be learned from such records are given by W. J. Fraser.

The dairy department of the University of Illinois bought the best and poorest cows from six different herds, brought them to the Uni-

versity and kept account of all the feed they consumed and of the milk and butterfat they produced. The record of the cows from five of the herds together with the cost, at the market price of feed, of the milk and butterfat produced by the different cows in exactly one year is given in Table 36.

TABLE 36.—BEST AND WORST COWS IN FIVE HERDS (FRASER)

| Number of cow | Pounds of milk | Pounds of fat | Cost per 100 lb. of milk | Cost per 1 lb. of butterfat |
|---|---|---|---|---|
| 83 | 11,794 | 382.4 | $0.61 | $0.19 |
| 84 | 8,157 | 324.0 | 0.87 | 0.21 |
| 85 | 9,592 | 406.3 | 0.75 | 0.18 |
| 86 | 3,098 | 119.2 | 1.56 | 0.40 |
| 93 | 9,473 | 358.6 | 0.76 | 0.20 |
| 94 | 7,846 | 282.1 | 0.87 | 0.21 |
| 95 | 14,841 | 469.0 | 0.56 | 0.18 |
| 96 | 7,686 | 324.1 | 0.80 | 0.22 |
| 97 | 8,563 | 291.0 | 0.78 | 0.23 |
| 98 | 1,411 | 52.8 | 2.77 | 0.74 |

By comparing the amount of milk, of fat and the cost thereof, the difference in the earning capacity of the several cows is shown in a striking manner. The best cow of all produced over 10 times as much milk as the poorest cow and produced it at 56 cts. per 100 lb., in marked contrast to the $2.77 required by the poorest cow to produce the same amount.

**Cow-testing Associations.**—In order that farmers may rid their herds of unprofitable animals cow-testing associations have been formed. The idea was originated by a woman in Denmark and after 3 years of agitation resulted in the formation of the first association on May 1, 1905. The idea spread to all of the principal dairying countries of the world.

The Newaygo County Dairy Testing Association of Fremont, Mich., founded by Helmer Rabild, was the first in the United States. In 4 years it increased the average fat yield of all its cows 49.5 lb. The associations are generally organized by dairymen acting in coöperation with the State Experiment Station, the farmers usually paying so much per cow to become members and agreeing to do certain things, such as to carry the tester to the next farm, etc. The station supplies the tester who is often a student working under the direction of a more experienced man. The tester not only does the particular work for which he is hired but interests the members of the association in better methods of feeding and caring for the herd and in other matters pertaining to the farm

on which advice is needed. The tester's salary and the expense of the materials used are defrayed by the money paid by the farmers.

In Table 37 are given some results obtained at a few associations in different parts of the Union.

TABLE 37.—MILK AND BUTTERFAT PRODUCTION, PERCENTAGE OF FAT, COST OF FEED AND RANGE OF VARIATION IN PRODUCTION AND COSTS AS DETERMINED BY A FEW COW-TESTING ASSOCIATIONS

| Association | Year | Number of herds | Herd average | | | | | | Range of variation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Number of cows | Amount of milk | Pounds of fat | Fat test, per cent. | Value of feed | Feed cost fat | Fat lbs. | | Value of feed | | Feed cost fat | |
| | | | | | | | | | Best cow | Worst cow | Best cow | Worst cow | Best cow | Worst cow |
| York-Fairhaven, Ill... | 1911–12 | 24 | 262 | 48 | 188 | 4.0 | $35.00 | $0.18 | 362 | 75 | $40 | $32 | $0.11 | $0.42 |
| Dickinson County, Kansas............ | ? | 19 | 134 | 50 | 246 | 4.1 | 35.59 | 0.14 | 546 | 59 | 56 | 33 | 0.10 | 0.56 |
| Pioneer, Iowa........ | 1909–10 | 23 | 337 | 55 | 232 | 4.2 | 36.25 | 0.16 | 413 | 64 | 32 | 35 | 0.08 | 0.21 |
| Benson, Iowa........ | 1909–10 | 23 | 351 | 50 | 180 | 3.6 | 32.14 | 0.18 | 321 | 75 | 45 | 24 | 0.14 | 0.32 |
| Richmond-Lewiston, Utah............... | 1911–12 | 26 | 498 | 68 | 251 | 4.0 | 38.44 | 0.15 | 446 | 72 | 47 | 29 | 0.10 | 0.39 |
| Blacksburg, Virginia.. | ? | 5 | 70[1] | 41 | 179 | 4.5 | 38.60[2] | 0.22[1] | 351 | 118 | 44 | 32 | 0.13[2] | 0.26[2] |
| Tennessee........... | 1907 & 1908 | 12 | 298 | 44 | 217 | 4.8 | 29.75 | 0.14 | 411 | 65 | 37 | 24 | 0.24 | 0.37 |
| Lyndeboro, New Hampshire ......... | 1911–12 | 26 | 326 | 65 | 244 | 3.8 | 73.03 | 0.30 | 464 | 40 | 107 | 45 | 0.23 | 0.74 |
| Ferrisdale, California.. | 1909 | 8 | 581 | 59 | 251 | 4.2 | ..... | .... | 627 | 83 | ... | ... | .... | .... |

[1] Six did not complete test.

[2] Cost of food and labor less value of manure.

**Sheltering Cattle.**—Proper shelter for the cattle is important. In regions experiencing little severe weather hardly more is required than a simple structure giving the animals protection from inclement weather and particularly against wet chilling storms, but in cold climates housing is a more serious matter for the herd is confined almost continuously for 15 weeks or more. Stabling becomes a question not merely of affording temporary protection to the cattle but primarily of providing them a home. Indeed the barn is even more than this for it is the place where the business of feeding the animals, milking them and developing them is carried on. So it is necessary to provide for the needs of the cattle, the convenience of the laborers and such conditions that milk can be drawn and handled without unduly exposing it to deteriorating influences. Furthermore, the business carried on in the barn is part of the business of the farm considered as a whole, consequently it should be operated in a way and from a place that makes it fit in well with other farm work; the location of the barn is important.

Barn building involves the choice of the type of barn best adapted to the farm and to the site. The barn should be arranged in such a way as to save work and it ought to be well-lighted, warm and ventilated.

Construction should be undertaken in a conservative spirit and only after careful planning for the present needs of the herd and with some foresight as to its probable growth and the demands of the future. At the outset it is most important to realize that the outlay called for, constitutes a fixed charge on the business, yet many dairyman fail to grasp the fact. Money invested in a dairy barn should pay 10 per cent. a year. So on a barn costing $1,000 and housing 20 cows there is a fixed charge of $5 a head, a sum that at 3.8 cts. a quart will take the sale of 131.5 qt. of milk from every cow to raise, which in most instances is excessive. The inevitable consequence of erecting too costly a barn is to lay a tax on the business, that the cows cannot pay off. Were they asked, the health officers of our large towns could point out many dairymen who have seriously curtailed their profits by investing too heavily in barn buildings. On the other hand, a good barn pays because the herd is made more comfortable and therefore more productive, the help better satisfied and, consequently, more efficient, and labor is expedited and made less costly because of careful planning and the introduction of devices that save toil. Dairymen owe it to themselves and to their trade to exercise good judgment in deciding how much capital they will invest in the barn and what sort of building it shall be.

**Types of Barns.**—Rarely is much consideration given as to what type of building is best adapted to the business for there is a strong tendency to build in the style of the district. While it is true that this style may have been settled on as the result of some experimenting with other types, more often it has become the fashion, simply as the result of thoughtless copying.

Broadly speaking, there are but two types of barns, rectangular and round barns for under these two all sorts of barns may be grouped thus:

1. Rectangular barns:

Three-story or basement barns.

Two-story or loft barns.

One-story or shed barns.

Double stabling barns.

2. Round barns.

**Basement Barns.**—In this country, in some places, particularly in the older dairy sections that are hilly, barns with basement stables are common. The objections to them are serious. The basements are often poorly drained, and they are generally built into the bank of the knoll on which the barn stands, in such a way as to entirely cut off the light and air from the cattle on two or three sides. So these stables are dark, damp, malodorous and often very hot in summer. The second floor is commonly used for horses and implements while on the third are the hay mows.

**Loft Barns.**—The loft barn is a good style for general farming. The walls are all above ground. The animals are kept on the ground floor

FIG. 13.—Basement barn, Sparks, Maryland.

*Courtesy of W. J. Fraser.*

FIG. 14.—Interior of an Illinois basement barn.

FIG. 15.—A Maryland loft barn.

FIG. 16.—A Missouri loft barn.

*Courtesy of Robert Burnett.*

FIG. 17.—Loft and shed barns of Deerfoot Farms, Southboro, Mass.

*Courtesy of C. W. Eddy.*

FIG. 18.—Shed barn of the Municipal Dairy, Cleveland Ohio.

and the feed is stored above them. These barns should be well-lighted, usually from two sides and an end at least; should have a ventilating system and the first floor should be ceiled off from the second so as to prevent dust from sifting down from above.

**Shed Barns.**—Shed barns can be easily enlarged and kept clean. So, in their most modern form they represent the latest development in cattle housing on farms where great attention is paid to the production of sanitary milk. In warm climates shed barns with siding only part way up are used, thus giving all necessary protection and at the same time being cool and having plenty of light and air. In some cases canvas curtains are provided to give additional protection from the elements when necessary. In California a form of shed barn known as the saw-tooth barn is popular.

*Courtesy of the DeLaval Separator Co.*

FIG. 19.—Saw-tooth dairy barn at Oakley, California.

**Double Stabling Barns.**—Double stabling barns are used in this way. The cattle are turned loose in what is often a reconstructed farm building or perhaps a low roughly built structure that has a dirt floor and a galvanized-iron or other inexpensive roof of some sort. Here the animals are fed their roughage and sometimes part of their grain. Watering troughs are placed so that the animals can drink whenever they want to. The cows are fed their grain and milked in another building which should be large enough to hold a third of the herd that milking may be done expeditiously and which is so built that clean milk may be easily produced therein. Directly after milking, the cattle are turned back into the other barn. This system avoids dust from bedding and provender, and since the cows are in the milking stable but a short time, it is kept clean and sweet. Besides these advantages the covered barnyard system gives the cows freedom of exercise at will and makes economical handling of the manure possible for it can be allowed to accumulate till work is slack when it can be carted right onto the land. An objection to the system is that twice the usual amount of bedding is required to keep the cows clean.

**Combination Barns.**—Combination barns for cows and horses are used in some places. They are usually the property of men who own little stock or of gentlemen farmers who keep cows for their own convenience and that of their neighbors. They have the advantage of enabling the saving of labor but they are difficult to clean, are likely to be infested with flies because of the horse dung that accumulates and often derive pungent odors from the horses and their droppings that taint the milk. Generally boards of health forbid the production of milk for sale, in such barns unless a solid wall—often brick or concrete is demanded—separates the two classes of stock.

FIG. 20.—Basement stable and milk house, Washington, D. C.

FIG. 21.—A New Jersey loft barn.

FIG. 22.—Shed barn of the U. S. Naval Academy.

FIG. 23.—A shed barn and a loft barn of the Fairfield Dairy Co., Caldwell, N. J.

FIG. 24.—Double stabling barn of the Maryland Agricultural Experiment Station.

FIG. 25.—Round barns of the University of Illinois.

**Round Barns.**—Round barns are strong and cheaper to build than rectangular plank frame barns. The silo helps to support the roof and is protected by the barn; being centrally located, it is easy to feed from, and the silo chute assists in ventilating the barn. It is easy to

handle hay in the mows for they are unobstructed. The objections raised to the round barns are: that they cannot be enlarged if the growth of the herd demands it, that they are difficult to light, that rectangular objects cannot be stored conveniently and that much space is wasted in the driveway.

**Barn Construction.**—The construction of a barn should be simple that it may be easily kept in sanitary condition and, except where the building is frankly temporary in character, it should be substantial. The foundation may be either of cement or of masonry set in cement, and should always rise far enough above the ground to prevent moisture from rotting the sills and frame. Indeed, it is best to run the foundation up to the bottom of the window sills. Either a mortised timber or plank frame may be used. The former is the older and commoner way of framing; the latter is the modern way and has come into vogue because it is cheaper, stronger and more easily and quickly built. Both ways of framing may be done in such a manner as to admit of either horizontal or of vertical siding. The walls should be windproof and as smooth as possible. In mild climates a single solid wall is warm enough, but in cold climates double walls with an air space between them are necessary. Either a gable or a gambrel roof may be used; the latter is self-supporting and gives ample loft room. Floors should be durable and impervious to water so that they may be non-absorptive and flushed frequently. They should be sloped slightly toward the gutters.

The standard width of barns is 36 ft.; they are usually built in bents either 10 or 14 ft. long, the former providing for three, and the latter for four, stalls between posts. The barn should be laid out so as to provide platforms and gutters for the cows, feeding alleys, cleaning alleys, a box stall for calving, bull pens, calf pens, a milk-room, and office for the herdsman and a dressing room for the help.

**Necessity of Good Planning.**—A little scientific management needs to be applied to the problems of the dairy barn and provision made for the conservation of energy. Fraser of the Illinois Station illustrates the unnecessary labor that bad planning entails, by supposing a milk-room to be located 50 ft. farther than need be from the cows, and calculating that the milker in carrying the milk back and forth, would cover 12 rods per cow each day, which in a herd of 60 cows would mean, 2¼ miles extra travel a day, or in a year, 164 extra miles for each milker.

**Plan of Round Barn.**—The round barn should not be much less than 60 ft. in diameter and it is not economy to have it much larger. It is arranged in a series of concentric circles formed by the silo, mangers, curbing, stalls, gutters and alley.

**Plan of Rectangular Barn.**—A rectangular dairy barn may be arranged in either of two ways. The cows usually stand in two rows and according to one arrangement, the cows face out, while in the other they face in.

Both methods have ardent advocates. The principal advantage claimed for heading the cows outward is that it makes the handling of the manure easy, for a cart or manure spreader can be driven down the cleaning alley and loaded from the gutters at each side. Also, this mode of stabling shows off the cows to visitors best. The advantage of heading the cows inward are: (1) feeding is more easily done with the feed alley in the middle of the barn; (2) the gutters, being near the windows, have direct sunlight; (3) the light falls on the rear quarters of the animals, making it easy to clean the animals and stalls, and to milk; (4) there is less confusion in letting the cows in and out; (5) the supporting posts can be placed in the line of the head rail which is at the narrowest part of the cow, thereby saving room. An objection to this arrangement is that the walls are likely to be splashed with dung and consequently to need careful attention.

In barns where the cows are headed out the cleaning alley forms a driveway down the middle of the barn, and parallel on each side in succession toward the wall is placed a gutter, a platform, a row of mangers and a feeding alley. The driveway is 9 ft. wide, the gutters are 16 in. wide, 10 in. deep next the platform and 4 in. deep next the alley; they should pitch 1 in. in 20 ft. toward the lower end of the stable. The platforms are 5 ft. wide. The rear partition of the mangers at the front of the platform is 6 in. wide. The manger is 3 ft. wide with the top 30 in. from the floor. The feed alley is 3 ft. 4 in. wide.

In barns where the cows face inward, a feed alley 6 ft. wide runs lengthwise down the middle of the barn, then in succession toward each wall and of the same dimensions as where the cows face outward, come the mangers, the platforms and the gutter, leaving a space of 4 or 5 ft. for the cleaning alley between the gutter and the wall.

**Barn Floor.**—Some of the details of construction should engage attention. The floors are sometimes of earth but they are usually either of wood or of concrete. Dirt floors are permitted only where the most primitive conditions obtain. They are insanitary because they cannot be kept clean, and they are objectionable because the larvæ of flies breed in them. The most wretched are those without gutters; those with concrete gutters having the cement work carried forward beneath the cows far enough to catch the urine are more decent. The first cost of wooden floors is generally less than that of cement ones but they are shorter lived; the length of service they give is dependent on the way they are built. They last longest either laid in contact with the earth so that moisture is constantly retained or laid so as to admit free circulation of air below. Under such conditions they possibly may last 6 to 10 years but where they are laid so that there is not sufficient air space below to admit free circulation of air they wear out in 3 to 5 years. Wooden floors are objectionable because they absorb urine and become foul-smelling. Concrete floors are best; they commonly have a thickness of 4 in. of grout and a

1-in. facing. The grout may be laid by ordinary farm labor but the facing should be done only by a skilled workman. The floors should be rounded up at the walls and in the corners to prevent dust accumulating in the joints and to facilitate cleaning.

**Platforms.**—The platform should have a pitch toward the gutter of 1 in. in 5 ft. It should be built of impervious material; concrete is generally used. It should be finished rough as with a board trowel to prevent the cows slipping. A depression in front of the tie, 14 in. wide and 1½ in. deep tends to keep the bedding in place, makes the cow stand more nearly level and prevents her slipping when reaching in the manger for feed. An objection to concrete is that it is a good conductor of heat and so tends to chill the cows, producing stiffness and udder inflammation. This may be quite overcome by the use of bedding or by placing a slatted rack over the concrete or by a movable floor about 3 ft. wide that is kept in place by two iron pins set in the concrete near the corners. If such floors are used they should be removed often for cleaning beneath them; in summer they are unnecessary. Vitrified brick, laid on a cement foundation and set in cement, is sometimes used for a platform and for floors. The same objections lie against it as against cement. The shortcomings of concrete have led to the use of cork brick and creosoted wood blocks for flooring. They are costly and somewhat expensive to put down, for they are set in cement and laid on a cement base. They are not easily cleaned but they are not cold and are easy on the feet of the animals.

**Alignment of the Animals.**—Aligning the cows on the platform requires some planning. The standard width of the stall is 3 ft. 6 in. The length of a stall for a Jersey should be from 4 ft. 4 in. to 4 ft. 10 in. and for a Holstein from 4 ft. 8 in. to 5 ft. 2 in.; the stalls for other common breeds fall between these extremes. If the stall is too long the droppings will fall on the platform, while if it is too short the cows will stand in the gutter and in either case soil themselves. There are three ways of meeting this difficulty. One is to make the platform on one side of the barn 5 ft. wide and on the other 4 ft. 6 in.; a second is to make the platform 4 in. wider at one end than at the other with a gradual slant between them; and the third is to use adjustable stanchions which may be set back 3 or 4 in. from the support for the short cows or ahead a like amount for the long ones.

**Stall Partitions.**—Stall partitions are not strictly necessary but are considered desirable by most dairymen. Wooden partitions are thoroughly objectionable because they become foul, are difficult to keep clean and detract from the appearance of the barn. Curved iron piping 1¼ in. in diameter makes the best partitions and needs be little more expensive than wood.

**Gutters.**—The gutters are probably more often botched in building, than any other part of the dairy barn, the tendency being to make them

too shallow and to give them too little pitch. They should be 18 in. wide with vertical sides 10 in. deep next the platform and 4 in. deep next the alley; they should have a slope of from 2 to 3 in. in every 40 ft. The gutters should be built of cement for sanitary reasons and to conserve all the fertility of the manure. The gutter should terminate in a 6-in. sewer pipe, the mouth of which should be covered with a solid top except when the stable is being washed out, when a perforated top should be substituted. A bell trap may be used to stop the nuisance that results from choking of the pipe with straw. The pipe should lead the liquid manure to a water-tight cesspool from which it is pumped and sprinkled on the land as needed.

**Alleys.**—The alleys should be sloped gently toward the gutters.

**Walls.**—The walls of the barn next the alleys should be plastered with cement from the floor to the window sills that spattered droppings may be easily cleaned off.

**Stanchions.**—There are several sorts of stanchions. The old-fashioned rigid stanchion had the advantage of keeping the cows clean but as it did not give enough freedom of movement to the cows nor permit them to lie in a natural position it has been largely superseded by those that give these advantages. The swing-chain stanchion has proved the most popular. Stanchions are made either of wood or iron pipe; the latter is comfortable for the cattle and is more durable than the former. These stanchions may be purchased at about $1.35 a piece and put up at home. They are hung from wooden framework or better from a framework of gas piping set in cement. The double-post slip-chain stanchion is comfortable and seems to be coming back into use.

**Mangers.**—Mangers in a few barns are dispensed with, feeding being done right on the floor. This practice is uncommon, most dairymen using mangers of which there are many styles and which are built of different materials. Wooden mangers were once practically universally used but they are being rapidly displaced because food gathered in the cracks making them sour and ill-smelling. Metal mangers are used but cannot be recommended because they lack durability. Cement mangers have proved the most popular; they are usually built in trough form which makes them easy to wash out. They should be 3 ft. wide. The bottom should be rounded and should be 1 or 2 in. above the platform; and the walls should be smooth and should rise 18¾ to 30 in. above the floor. The objections are raised to trough mangers that the cows rob one another of food and that tubercular animals readily spread infection in them. The first difficulty is met by providing metal partitions that can be dropped into place at feeding time and raised thereafter. As to the second its truth may be admitted, but there are so many ways for the tubercular animal to spread infection that it seems hopeless to prevent her doing so as long as she is a member of the herd. Removing her therefrom is the only remedy.

**Milk Room.**—The milk room is a highly valuable appurtenance of the dairy barn. In even the smallest dairies some sort of a separate room should be provided for the cans into which the milk is poured from the milkers' pails. This is necessary because milk absorbs odors very readily and if it stands exposed in the stable it is sure to acquire a more or less decided taint. The "cowy" flavor of milk, to which so many object, is taken on in the stable and is in reality derived from the manure rather than the cows. Dairymen doing a considerable business need a good milk room. It should be conveniently located, easy to enter and leave, airy, well-lighted and large enough for the milkers to use without crowding. In it the milk is weighed, sampled and strained and the milk records posted. In summer it should be thoroughly screened.

**Office.**—There should be an office for the herdsman where he can put his books, file his records, keep the medicines and the instruments such as milk-tubes, teat-openers and the like that should rightfully be in his charge.

**Dressing Room.**—The dressing room for the help should be light and should be provided with a bench, mirror, lockers for the clothes and, if running water is available, with open plumbing, otherwise hand basins must be used. Individual or paper towels should be supplied; the roller towel is as insanitary in the dairy barn as it is anywhere else. The dressing room including the lockers should be inspected for cleanliness often. In barns too small to afford a dressing room, the herdsman's office may be used for this purpose.

**Ceiling.**—Except in certain types of shed barns it is necessary to carefully ceil the part of the stable where cows are kept in order to prevent dirt from sifting down from above. The ceiling should not be more than 9 ft. above the floor and, except where wagons are to be driven into the barn, a clearance of 7 ft. 6 in. between the floor and bottom of the ceiling joists is sufficient. Stables of greater height are apt to be cold because the animal heat is likely to be insufficient to warm them. Moreover they are apt to be draughty and in some there is a tendency for air to stagnate at the top.

**Lighting.**—The lighting of a barn demands careful attention. Until recently dairy barns were dark or at best poorly lighted. Now it is generally recognized that plenty of light is necessary for the comfort of the animals, to reduce eyestrain among the employees, to facilitate work and to produce a cheerful atmosphere. Also, it is known that sunlight tends to enfeeble and to destroy germ life. The amount of light needed in a dairy barn has not been definitely determined either by experiment or practice, but 4 sq. ft. of window space per animal or a minimum of 2 sq. ft. per 500 cu. ft. of air space is believed to be right and emphasis is laid on the fact that the windows must be so placed that the light is evenly distributed. A barn with the light all at one end, or one lighted so as to

produce a blotched effect, is unsatisfactory. In placing the windows it should be borne in mind that the barn is lighted both by direct sunlight and by reflected light from the sky.

**Ventilation.**—Despite the vast amount of study that has been given to ventilation much is yet to be learned about it and about the effect of poor ventilation on health so that dogmatic opinions in these matters are out of place. Researches now under way may considerably modify our present beliefs. The ventilation of dairy barns is highly important. The objects are to provide for: (1) the well-being of the herd; (2) the comfort of the workmen; (3) the removal of odors likely to impart bad flavors to this milk; (4) the carrying off of moisture transpired by the animals, before it has a chance to condense on the barn and rot it. The lighting, ventilating and heating of a barn are related problems, in fact so closely so, that it is generally true that what affects one, in some measure does the others.

The temperature at which dairy cows should be kept has not been determined; Eckles is of the opinion that as suitable as any is between 40° and 50°F., while King thinks it likely that for animals being fed high 45° to 50°F. is best, that those on a maintenance ration will do better and at lower cost at temperatures between 55° and 65°F. To warm barns, reliance is usually placed on the heat given off by animals themselves.

**Ventilation by Windows.**—Satisfactory ventilation can be secured from windows if there are enough of them and if they are properly disposed; they should be placed well up the wall usually with the bottoms of the frames at the level of, or somewhat higher than, the backs of the cattle and they should be set flush with the wall that there may be no ledge whereon dust may settle. It is best to have them pivoted at the middle of the sides of the window so that they can be tipped inward leaving openings at the top and bottom. It is almost as good to have them hinged at the bottom so that they can be opened inward at the tops and so admit the air above the animals. Windows that open by sliding sideways or past each other are not so well adapted to dairy barns as other styles are. When window ventilation is practised, the hay and silage chutes serve as outlets for the foul air.

**The King System.**—The system of ventilating dairy barns most widely used in the United States was introduced in the summer of 1889 by King of the University of Wisconsin and is known as the King system. It has the merits of being efficient, simple of construction and not so costly but that most farmers can afford to use it. The King system has been developed on the theory that since carbonic acid gas is the chief impurity in stables, and since this gas is heavier than pure air, foul air is likely to be found in largest quantities near the floor, therefore, outlets for it are placed near the floor. To be serviceable the system must be installed in a barn that is tight, for the air currents of a loosely built

barn prevent it from working successfully. The circulation in and out of the building is through specially constructed flues. The inlets are placed on all sides of the barn and take air from the outside of the building, being located between the walls if they are hollow or, if they are of solid masonry, through pipes and other special contrivances. The inlets on the outside, open at the level of the window sill or lower, and on the inside, near the ceiling. This prevents the warm air rushing out as it would if the inlets were carried straight through the walls, and on the inside allows the fresh, cool, heavy outside air to slowly spread through the stable without causing drafts. The combined area of the inlets should equal or exceed that of the outlets, for air cannot leave the stable faster than it comes in.

The outlets are the vital part of the King system and so they should be built with the greatest of care. Except where openings are provided they should be made with permanently air-tight walls that only air from the space to be ventilated may contribute to the current passing through them. They should be of ample and uniform cross-section throughout their length; it is the smallest section that determines the capacity of the duct. Out-takes of circular or square cross-section are preferable to long, narrow ones because there is relatively less surface to cool the air and to make friction, hence there is less loss of pressure and greater flow of air. The suctional effect of the wind and the motive power for ventilation generated by temperature differences, increase with the height; but friction is augmented by height as it is also by bends and its effect in decreasing motive power must be taken into account. The outlets are located in the line of the stanchions in those barns in which the cows face outward, and against the walls in those wherein the cows face inward. The ducts are built of wood because it is a non-conductor of heat, and are extended upward through the cupola or through the roof, either right above the stanchions, if built in the stanchion line, or near the eaves, if built against the walls. The latter way is least satisfactory because it gives the barn an unsightly appearance, since the ducts have to be carried above the ridge in order that downdrafts may not cause them to draw faultily. At the top the duct is covered by a hood to keep out rain and to increase the circulation by the passing of air currents over the top but care should be taken not to put the hood so close to the top of the outlet flue as to impede circulation. For several reasons the outlets exhaust near the floor. First, by doing so they effect the greatest movement of air possible with the maintenance of proper temperatures. Second, by taking air at this level they tend to promptly remove odors of the animals and of the manure; they also draw out the breathed air somewhat directly because on being exhaled from the lungs it is cooled to about 81°F., at which temperature, on account of its carbon dioxide content, it is heavier than the surrounding air and tends to sink. Third, since it is the air of the lower levels that is

breathed, it is advantageous to renew it frequently, and that, the location of the mouths of the outlets near the floor accomplishes. Near the ceiling the outlets are provided with registers or intakes that are kept closed in cool weather but in hot are opened for the double purpose of cooling the barn and increasing the draft.

In small barns a single large outlet flue is best; large barns require several of suitable size. King has stated that a ventilating flue 2 by 2 ft. through which air moves at 295 ft. per minute gives sufficient air for 20 dairy cows. However, he points out that it is the temperature in the outlet flue that largely determines the draft and that the motive power for ventilation due to temperature, increases with the height so that this factor should be taken into account in practice and he holds that out-takes and intakes for cow barns should provide for not less than 30 sq. in. per head, when the out-take has a height of 30 ft.; if the out-take is shorter the area should be greater, if higher it may be less. A 20-ft. out-take should require about 36 sq. in. per head instead of 30.

**Canadian Experiments.**—Grisdale and Archibald of the Dominion Experimental Farms at Ottawa have made an interesting study of the

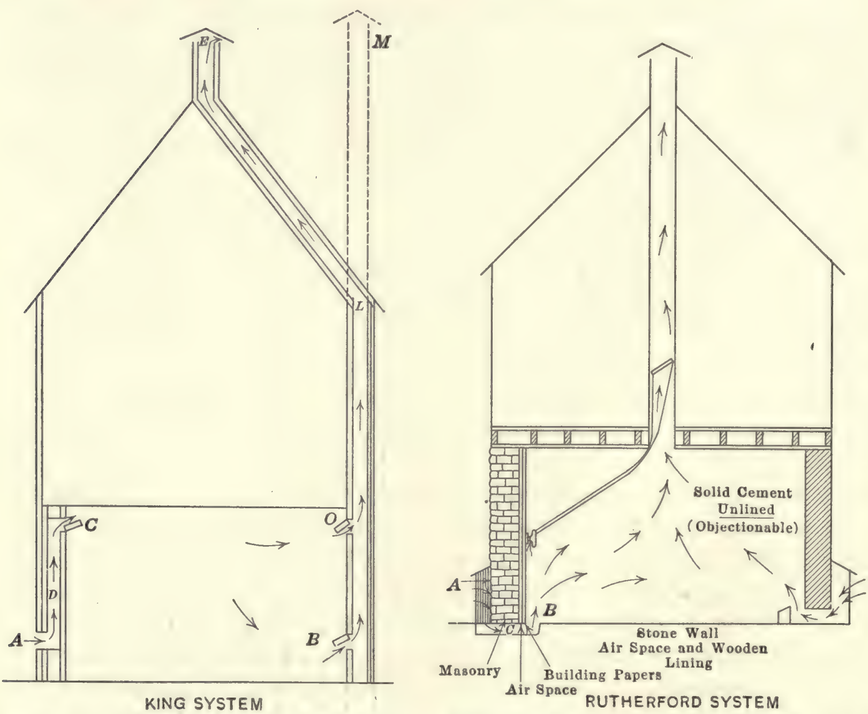



FIG. 26.—The King and the Rutherford systems of ventilation. (From Bul. 72, Dominion Experimental Farms.)

ventilation of farm buildings. Their researches include experiments with the King system, The Rutherford system, with ventilation through pierced walls, and with ventilation through muslin curtains.

These authors state that they find the King system unsatisfactory in the climate of Ottawa and suggest that it is better suited for warmer countries.

**Rutherford System.**—They find that in Canada the Rutherford system gives the best results. It is built on the theory that the ventilated warm air will rise in spite of the high specific gravity consequent on its high content of carbon dioxide gas and water. They believe that with the Rutherford system there is less tendency for moisture to precipitate from the admixture of cold air with moist warm air than with the King system. The fresh outside air enters the stable at or near floor level through inlets that pass under or pass through the barn walls while the foul air is carried off through one or more outlet ducts built of boards running vertically, two-ply, with an inch air space and two papers between them. The air space provides insulation against cold and so prevents condensation of moisture in the duct. These ducts are carried to the ridge of the roof and are hooded, having 15 in. of air space between the mouth of the duct and the wood. In stables where 600 to 800 cu. ft. of air space is provided for each cow 2 years old and over, there should be 15 sq. in. or somewhat more of controlled outlet area and 8 sq. in. or slightly more of controlled inlet area per cow. Controls or dampers are needed because cold air, being much heavier than warm, causes more rapid inflow and outflow of air in very cold weather, than in warm, making it necessary to control the circulation to prevent barns becoming too chilly in cold weather and too warm in hot.

The advantages claimed for the Rutherford system are:

1. Ease of installation in both old and new buildings.
2. Adaptability to all classes of stables.
3. Suitability to variety of weather and climate.
4. Facility of operating and controls.
5. Effectiveness of control of all the stable.

**Ventilation by Pierced Walls.**—Ventilation by pierced walls was found to be simple and cheap; round or square holes are pierced in all the sides of the stable exposed to outside air. In a stable 30 by 36 ft. these holes should be 4 in. in diameter and spaced 3 ft. apart, or they should be 6 in. in diameter and be placed 6 ft. apart. The holes may pass straight through the walls thus giving a direct current, or in walls built with an air space a hole may be placed on the outside between the studs near the ground and one on the inside a little above the cattles' backs, thus giving a deflected current in the space between the walls. The air enters the barn through the holes on the side exposed to the wind and the stable air escapes through the other holes, consequently holes that on one day serve

as inlets, on another, if the direction of the wind has changed, may serve as outlets. The holes should have covers or other devices for regulating the passage of the air in and out.

**Ventilation by Curtains.**—The efficiency of muslin-curtain ventilation was tested in a well-lighted stable having a ground floor of 100 by 25 ft. and a 10-ft. ceiling. On each side of the building were 10 windows 2½ by 4 ft. in area, located 6 ft. from the floor and extending to within about 18 in. of the ceiling.

The advantages of the system were found to be: (1) that by taking great care the stable could be ventilated by means of the muslin; the cheese cloth proved better than the cotton because the air passed through it more easily; and (2) that this kind of ventilation is cheap and better than none. The objections to the system are: (1) that great watchfulness is required to insure a fair measure of success; (2) there is danger of an excessive fall or rise of temperature during the night on account of a rise or fall of the wind; (3) the muslin darkens the windows making the stable dark, gloomy and damp; (4) changing directions of air currents wet the muslin and prevent foul air escaping so that the curtains become dirty and insanitary.

**Watering Cows.**—Cows should be supplied with plenty of pure water. It is not safe to have impure water on the premises because some one may be made ill by drinking it, or the milk may be infected by it or possibly the cows may become infected with parasites through its use. On the small farms cows get water in the barnyard or pasture but in the larger dairies the water is piped direct to the mangers.

*Courtesy of C. W. Eddy.*

FIG. 27.—Manure trench, Cooley Farms, Cleveland, Ohio.

**Care of the Manure.**—The conservation and handling of the manure should be carefully attended to by the dairy farmer because the return of its fertility to the soil contributes to his financial success. A 1,000-lb.

cow voids approximately 46 lbs. of dung and 27 lbs. of urine a day which together make about 12 tons or with bedding included about 15 tons annually. Under proper management at least 80 per cent. of the fertility can be returned to the soil. If manure is to be stored, plenty of litter must be used and the manure must be kept moist and compacted. To prevent loss from leaching it must either be protected by a roof or kept in a waterproofed cement-lined pit which will retain all fluids. Manure cannot be stored without creating more or less of a nuisance. It will stink, it will breed flies and unless unusual pains are taken, it will be so disposed of in the barnyard that the cows will mouth it, and soil themselves by walking through it or by wading in the puddles that are formed by its leachings in wet weather. Manure is often mixed with land plaster, thrown through a trap door into the basement of the barn and stored there. It is not a bad way of keeping the manure but it is attractive to flies and rats, and is malodorous so that it is offensive, especially where hogs are kept in the manure in the belief that they keep down the stench. Less objectionably, manure is piled in sheds or lean-tos some distance from the barn. The most wasteful way to keep manure is to heap it under the eaves. It has been common for boards of health to require manure to be removed a certain distance from the barn. Such regulations are probably justified chiefly on the ground that they lessen the likelihood of milk being deteriorated by odors but they are not very practical for it is not *where*, but *how* the manure is kept that is of importance, and they often are the cause of needless bickering between inspectors and owners.

It is best to have some settled practice in applying the manure to the land. The urine is the most difficult to deal with. There are two ways of saving it; the first is to absorb it completely by the liberal use of bedding and the second is to lead it to an underground waterproofed cement cistern from which it may be pumped into a sprinkler or onto a loaded manure-spreader and applied to the land.

The dung may be loaded directly into a cart or manure-spreader and hauled out and spread on the land as soon as there is a full load. The objections to this are: (1) that in winter in order to keep the manure from freezing it is often necessary to carry it out before a full load has been obtained; (2) that the land is frequently in such condition that it is impossible to drive on it; and (3) that the land that is to be fertilized is not always ready for the manure. In spite of these drawbacks it is becoming more generally the practice to apply the manure directly to the land rather than to store it.

Manure is handled in different ways. When the construction of the barn permits it the cart or manure-spreader are driven into the barn and loaded from the gutters. Some barns are equipped with manure-carriers of which there are two kinds, the rod-track and the rigid-track. In each an elongated tank usually of galvanized iron is suspended from an over-

head track running immediately behind the cows and along the edge of the manure gutter. In the rod-track the carrier runs on a cable wire which is stretched so as to permit the carrier to run by gravity from the barn to the dumping point where by striking a trigger it is discharged automatically. Since this type of carrier cannot be raised and lowered, much labor is required in lifting the manure to fill it. The end of the rod-track is attached to a post in such a way that it may be kept at proper tension by the use of a turn buckle which, except when new, is apt to require frequent attention and so is annoying.

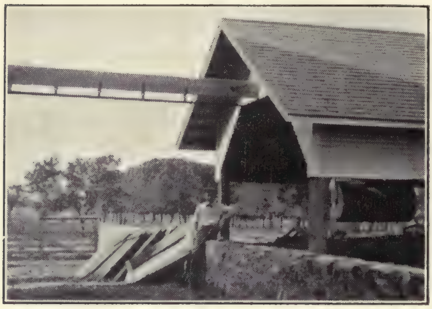


Fig. 28.—Manure carrier.

The rigid-track carrier is more expensive than the other but is more satisfactory. An overhead trestlework supports a rigid iron track on which, suspended below on a swiveled iron frame, the carrier runs. It is pushed along the gutter as the stables are cleaned, all high-lifting of the manure being avoided by lowering the carrier till it little more than clears the floor. When the carrier is full it is raised by a gear arrangement and pushed out of the barn to the dumping point where it is emptied by pulling a trigger.

**Litter.**—The availability and cost of bedding materials usually determines the choice as to which shall be used; other qualities to be considrred are their absorptive power and cleanliness. Doane of the Maryland Station made a series of tests to determine the value of different materials for litter, comparing them with the material most widely used by dairymen for the purpose, whole wheat straw, as a standard. It was found that chopped wheat straw is easily kicked about and packs down closely so that more is required to keep the cows clean. Rye straw which is highly esteemed for horse litter seemed poorly adapted for cows because it is hard and stiff and has low absorptive capacity. Barley straw is not used because the beards irritate the animals. About one-third more by weight was required of corn stover but it is not easily shoved about and keeps the cows cleaner. All of these materials were a little dusty but not objectionably so. Wet or mouldy straw is wholly unfit for bedding. In some places weeds and fallen autumn leaves are used for bedding; they are to be condemned for litter because of the dust they contain. Sawdust stayed in place better and kept the cows cleaner than any other bedding. It was often damp but this produced no ill effects. Sawdust makes the manure so light that loss of ammonia may occur; it decays slowly and tends to loosen up the soil so that it is possibly not the thing to apply to a light sandy soil, but on heavy ones it is unlikely to do harm and may be

distinctly beneficial. It is said that the tannic acid which results from the application of large quantities of oak sawdust has sometimes been injurious to the land. Shavings have all the good qualities of sawdust but being light are scattered by a strong breeze. Both sawdust and shavings are free from dust and nearly so from mould and bacteria; on the whole they probably make the best litters. Tables 38 and 39 show the absorptive powers Doane found different bedding materials to have, and the amount of them required daily.

Table 38.—Absorptive Powers of Bedding Materials (Doane)

| Material | Water absorbed per pound of bedding | Pounds of bedding required to absorb liquid manure from one cow for 16 hr. | Pounds of bedding required to absorb liquid manure for 24 hr. |
|---|---|---|---|
| Cut stover | 2.5 | 2.8 | 4.0 |
| Cut wheat straw | 2.0 | 3.3 | 5.0 |
| Whole wheat straw | 2.0 | 3.3 | 5.0 |
| Sawdust | 0.8 | 8.3 | 12.5 |
| Shavings | 2.8 | 3.0 | 4.4 |

Table 39.—Amount of Litter Required Daily per Cow for 16 Hr. Stabling[1]

| | |
|---|---|
| Cut wheat straw | 2.9 |
| Whole wheat straw | 2.3 |
| Cut corn stover | 3.2 |
| Sawdust | 11.0 |
| Shavings | 2.7 |

[1] Except where bedding is regulated to absorb all the liquid manure, it is doubtful if materially more bedding would be required for 24 hr. stabling.

**Vermin and Flies.**—The vermin that annoy most in dairy barns are rats, mice, lice, fleas and ticks.

The fly nuisance is very troublesome to deal with. In the United States three varieties of flies, the stable fly, the horn fly and the house fly annoy cattle. In some States the stable fly inflicts severe losses but though it is conceivable that it might spread anthrax it is not believed that either it or the horn fly spread diseases that commonly afflict man but the house fly is known to be a disseminator of typhoid fever, probably of infantile diarrhea and other intestinal infections and of tuberculosis. The stable fly deposits its eggs in various kinds of straw, the horn fly in cow manure and the house fly in horse manure and other ordure. As these materials are abundant around dairy barns there are bound to be flies. It is the common belief that the falling off of the milk flow in the latter part of summer is largely due to the pestering of the cows by flies but the prime reasons for the decrease are disinclination of the cows to eat and shortness of pasturage and water, the flies being only a minor contributing

cause. At several of the experiment stations the efficacy of various mixtures that are supposed to keep flies off the animals has been tested. The mixtures are usually some coal-tar product combined with fish oil, resin, pine tar or sometimes with tobacco. Several, if applied frequently, kept off the flies but their use did not result in an increase, either in milk flow or butterfat production.

The fly pest has to be fought in barns, dairies and city milk plants quite as vigorously as it is fought elsewhere. In the stable, although they cannot bite, the flies annoy the animals. Flies are very fond of milk and swarm into dairies and city milk plants where they are likely to infect it. The best way to keep down the flies is to deprive them of breeding places. This means that manure bins should be screened or in other ways be made flyproof and that the manure should be carefully swept up from the stables for if it is permitted to gather in small quantities on the ground or in crevices in the floor it will surely yield its quota of flies. Also it is important to have the manure removed at such frequent intervals, usually less than 10 days, that there will not be time for a generation of flies to develop. The attempt has been made to control the breeding of flies by mixing various substances with the manure. The labor involved and the cost have prevented the practice from being generally adopted. The U. S. Department of Agriculture finds borax in the proportion of 0.62 lb. to 8 bu. of manure to be as efficacious as anything for this purpose. Garbage must be kept in covered receptacles and removed often. Also, privy vaults should be built so as to be flyproof and the seats should have covers that shut automatically. These measures should be supplemented by effective screening, the use of fly traps of the Hodges or of the Minnesota patterns and of sticky but not of poison flypaper and by swatting the fly that eludes these guards.

The Florida State Board of Health made an interesting study of the breeding of flies in the floors of the horse stables in Jacksonville. There were 944 stables having dirt floors and 113, that were typical of the average of such stables in the city, were given special study. The soil was examined to a depth of 6 in. In 94 per cent. of the stables where there were no chickens to eat them up, larvæ were found; in the other 6 per cent. the soil had been removed to a depth of 3 or 4 in. a few days before inspection was made. Some of the floors had been swept clean of manure and litter but even in these, larvæ were found at a depth of 1 to 3 in. Soft wet ground, that which had been wet by urine, was most favorable to the larvæ. In hard dry ground larvæ were not found. In the city there were 136 horse stables with wooden and 16 with cement or brick floors. Fifty-two of these wood and cement floored stables were carefully investigated. In none of them were there chickens. In 70 per cent. of the floors larvæ were breeding and in nearly one-half of these the presence of larvæ was due to the fact that there were cracks, broken

boards and depressions where the broom did not reach; in the remainder it was due to carelessness on the part of the proprietor. In 23 per cent. of the wood floor stables flies were breeding *under* the floors and this figure is low as about one-half of the stables inspected were of such construction that flies might breed beneath the floors but precluded determination of whether they were doing so or not. Two factors lead to the breeding of flies under the wooden floors. First, in some stables the floors were not tight and so permitted urine and particles of fly-blown manure to fall beneath the floor where the warmth and moisture were favorable to larval development. Second, in stables of this sort having loose foundations flies will oviposit in suitable material that they find beneath the barns.

Larvæ were found in many manure heaps but often the manure had been hauled away a short while before inspection so that in this particular the percentage of positive findings, 38 per cent. of all the stables, was low.

**Mosquitos.**—Mosquitos, like flies, greatly annoy cattle and the writer has seen invasions of dairy districts by certain varieties of salt marsh mosquitos that were really disturbing but speaking broadly it is unusual for mosquitos to trouble herds greatly. To the farmers themselves they may do serious injury for *anopheles* mosquitos, infected with malaria transmit the disease to man causing him to be sickly and listless, consequently his business suffers. To avoid such misfortune and to prevent the family from being pestered by the ordinary house mosquito, *culex*, rain barrels and cisterns should be kept tightly covered that mosquitos cannot enter them to lay their eggs. There should be good drainage about the house and barn, for in puddles that are permanent enough to last 10 days the insects will mature. Pools around manure heaps, cesspools and the water that accumulates in privy vaults, also make prolific breeding places. Sagging gutters likewise furnish their quota of mosquitos. Places that cannot be drained can be rendered unfit for breeding by spraying them with oil.

**Milk Houses.**—Besides barns, milk houses are required on dairy farms and ice houses are so useful as to be almost a necessity.

Milk or dairy houses vary a great deal in type because they must be suited to the character of the dairyman's business; when the milk is shipped in bulk a very simple structure suffices but where a producer carries on a retail business a more elaborate building is required. The purpose of a milk house is to afford a place to which the milk may be carried as soon as it is drawn from the cow and in which it may be cooled, made ready for shipment or delivery, and be stored. Milk houses are sometimes in the dairyman's dwelling or occasionally in one end of his ice house, more often in or attached to the barn but are usually in a separate building a short distance from the barn. Of these situations the least favorable

is the first because it is practically impossible to keep the business of the household separate from that of the dairy. Members of the family, especially the children, run in and out of the milk room; things that should be kept in the kitchen find their way into the dairy room; there, clothes that should be hung in a closet or in the shed find a convenient hook; the milk-room doors are left ajar; odors from the kitchen often permeate the milk room and other petty things interfere with the routine of well-ordered dairy business. Most objectionable, are those dairy rooms that are located in the cellars of houses, for they are likely to be dark, damp and poorly

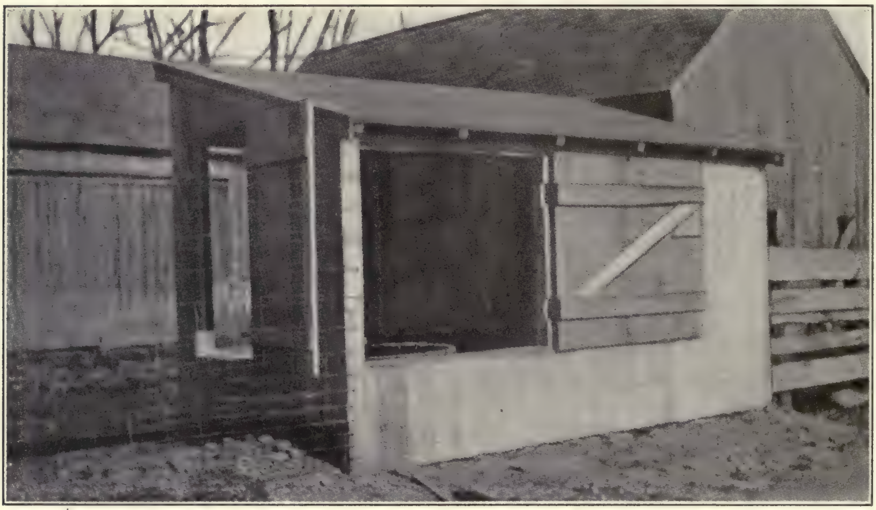


FIG. 29.—Inexpensive dairy house for farmer handling milk in bulk. (40th Annual Report, Boston Health Department.)

ventilated besides which dirt is apt to sift down from the floors above and be blown in from the ground. Another objection to having the milk room in the house is that in case infectious disease appears in the household such a location is most unfortunate.

The location of the milk room in or attached to the barn is usually unsatisfactory chiefly because of the difficulty of keeping out odors, but also because it is hard to keep the room scrupulously clean, to prevent it from being overrun by the help and to keep out flies, rats and other vermin. However, some dairymen do overcome these difficulties and maintain thoroughly satisfactory milk rooms within their barns.

Altogether the best location for the dairy house is detached from the barn and 150 to 200 ft. from it and, if possible, near the dwelling. The object of the milk house is to have a place where the milk can be weighed, tested clarified, separated, cooled, put in its final container and stored in surroundings free from odor, dust and confusion. Also it is the intention to provide a place where the workman may attend to these things

free from the interruption of outsiders. It is obvious that the purpose is most likely to be attained in a building devoted solely to the handling of milk and especially designed therefor.

The dairy house should be placed so as to save the milkers as many steps as possible in going to and from the milk house with the milk. Usually this puts the building about midway of the length of the barn. On some farms the milkers instead of carrying the milk from each cow to the milk house to weigh, sample and record it, take it for this purpose to a small room within the barn and then dump it into a funnel connected by a line of seamless "sanitary" piping with the milk house into which it flows by gravity through the pipe. Such an arrangement is convenient and labor-saving but its success depends almost wholly on the care that is taken to keep the pipe clean and sterile. In dairies where the milk of the individual cows is not weighed the milkers often pour the milk into a large can, which when full is carried into the milk house. This can should not be set in the stable proper for filling but without in an adjoining room or some other convenient place where it will be protected from the odors of the animals, from dust, flies and the attention of cats.

In addition to being located conveniently to the barn, the milk house should be situated where it will have good drainage both for its own wastes and for the surface and ground water without, where it will be free from dust and odor and where an abundant supply of pure water is accessible. In a country of uneven topography it is usually not difficult to secure good drainage but on the prairies it often is so and considerable labor is required to make the house and the land immediately around it dry. If the dairy house is on bare ground it will be dusty, consequently the labor of keeping the milk and utensils clean will be greatly increased. The ground around the dairy house should be turfed. The driveway to the store-room should be run so as not to pass beneath the windows of the milk room and should be oiled or paved if it is prone to get dusty. Dust raised by automobiles and wagons will be troublesome if the dairy house is not located a considerable distance from the highway. Odors are usually easily avoided if care is taken not to put the milk house where it gets them from the kitchen, hen houses, hog pens, latrines or manure piles. Proximity to the last three of these is particularly objectionable for in addition to being a source of evil odors they attract or breed flies, making it exceedingly difficult to keep the dairy house free from these filthy insects.

An abundant supply of water in the dairy house is essential to cleanliness and running water is all but indispensable, for a dairyman can ill afford to spend his time toting water. Where there is a public water supply it often can be piped to the dairy house; where there is none water may be pumped by a windmill, hydraulic ram, or gasolene engine to a reservoir or tank whence it will flow by gravity to the dairy house.

Dairy houses are usually built in an inexpensive way; so in their

construction, wood is commonly used but they may be of brick, cement or masonry. Small dairies having but few cows and delivering milk in bulk often have wood frame milk houses of but a single room with wooden floors and tanks. They, and all other dairy houses, should be well-lighted, well-ventilated and should be completely screened to keep out flies and other insects. They should have well-fitting doors that should be kept closed in order to keep out cats, hens and rats whose droppings make sanitary milk production impossible. Within, the houses should have shelves whereon the cans and other utensils can be kept inverted and without, there should be a sunning rack for airing the tinware. If cans of milk are cooled with water in tanks it should stand well above the level of the milk in the can and the milk should be mixed with a clean stirrer till brought to near the desired temperature when the covers should be put on the cans. Water in the tanks should be kept clean and covers for the tanks are recommended. Warm milk should not be mixed with cold milk nor new milk with old. Milk is often injured by the use of unclean or sour cloths to wipe the cans or other utensils. These towels should either be washed carefully and dried quickly in the sun, or else should be of such cheap material that they can be thrown away after being once used.

For dairies having 25 cows a 10 by 20-ft. three-room milk house is suitable. The floor should be of concrete and should be rounded at the walls and corners to facilitate cleaning and should be sloped gently to a drain in the middle. The walls should be of cement plaster on metal lathing to the windows, above which they may be of plaster or of matched stuff painted white—preferably with waterproof enamel. The windows should be flush with the walls. The boiler room, containing the boiler, coal bins and workbench is placed as far as possible from the milk-handling room in order to protect it from coal dust and ashes. There should be two doors to the boiler room, one opening outside and the other to the washroom.

The washroom should be supplied with hot and cold water and should be equipped with a sink, bottle washer, bottle rack and can racks. There must be apparatus for sterilizing utensils. For small farms Ayres's device which is described in *Farmers' Bulletin* No. 748 of the U. S. Department of Agriculture will suffice but on the larger dairy farms sterilizing apparatus such as is used for bottles and cans in city milk plants, is needed. The bottle cases should be kept in this room. Besides the door to the boiler room there should be one opening outside and one to the milk-handling room; the milk-handling room should contain the cooler, separator, concrete storage tanks and ice chest if there is one.

If milk is bottled or butter is made at the dairy a 16 by 30-ft. four-room dairy house is required. At one end should be placed the receiving room where milk is weighed and tested. It is then put through a

clarifier or poured directly in a funnel and run by gravity in a pipe through the wall over the cooler in the bottling room. This room contains the bottling machine, the capping machine, the separator and ice box. The pressure sterilizer which is located in the washroom at one end opens into the bottling room which is convenient, for it makes it possible to get the bottles and other necessary utensils into the milk room without exposing them to dust and unnecessary handling. The bottling room is connected by a door to the washroom and that in like manner to the boiler room. These two rooms are located at one end of the building and contain the usual conveniences, apparatus and supplies.

There must be hot water in the milk house and getting it is often something of a problem to dairymen of limited means. The least satisfactory way of heating water is to do it in a tin boiler on a stove; but little better is that of heating it in a bricked-up iron kettle; more convenient is a galvanized-iron tank placed over a large kerosene burner. When gas is available instantaneous gas heaters give satisfaction, but a 1 to 2-hp. steam boiler is best of all for by turning the steam into the wash tank hot water is quickly obtained and moreover the steam is available for sterilizing bottles and utensils, for driving the clarifier and separator and for heating skim-milk for calves. The first cost of a steam boiler is considerable but in the end it is cheapest and best. It is unsafe to have heating appliances in milk rooms that are in barns.

**Ice Houses.**—Since by the use of well or spring water milk can seldom be cooled to 50°F. whereas it can be cooled to 40°F. in tanks containing water and floating ice, it is highly desirable for a farmer to have ice on the premises in order that he may keep his milk in prime condition. Where climatic conditions permit it farmers harvest their own ice. The U. S. Department of Agriculture estimates that where whole milk is sold, in the Northern States 1.5 tons, and in the Southern 2 tons, of ice a year are required to cool the milk of one cow. Only about 1,000 lbs. of ice per cow are required where the farmer is delivering cream three times a week. Of course these estimates assume properly constructed ice houses details for which are issued by the Federal Government and several State boards.

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## CHAPTER IV

# SANITARY MILK PRODUCTION

**Milk Must Satisfy the Purchaser.**—To bring good price, milk must have good food value and certain other qualities that are affected by the sanitary conditions under which it is produced. Care must be taken to keep milk clean.

**Dirty Milk.**—The dirt that gets into milk is of many sorts and comes from different sources. The large particles are noticed and objected to by consumers but the invisible dirt that comes from a foul strainer cloth or from the film of milk that dries on the carelessly washed pail escapes attention, yet it is quite as likely to deterioriate the milk. Dirt from various sources is not equally objectionable. That blown from a newly ploughed field is regarded with less aversion than that blown from a much-used driveway because the one is relatively free from animal excretions whereas the other is likely to contain them. The dirt or dust raised in a barn by tumbling hay from the mows is of a different sort than that raised by currying the cows. The dirt from utensils, from soil, from dung, from the skin of animals and from other sources each has its peculiar character and may be expected to affect milk differently. Wherein does this difference chiefly lie? Not in the dirt itself, but in the bacteria attached to it. Practically all dirt that gets into milk carries its quota of bacteria but some of it is much more heavily seeded with germs and dirt from some sources is more likely than that from others to carry those germs that markedly affect milk, or those that infect people who drink it. So all dirt and all sources of pollution are not of equal importance. Bacteria are washed into milk from the dirt that falls into it and much dirt, as for instance manure, partially dissolves; consequently the removal of visible particles by straining or centrifugalizing does not restore milk to its original purity, for these operations leave bacteria in the milk. To keep dirt out of milk is comparatively easy but once it is in, to remove it completely is impossible. Milk once contaminated remains so. Therefore, cleanliness at the farm is of the utmost importance, for if it is neglected there all the pains that are taken with the milk afterward are in part nullified. Since clean milk ordinarily contains but few bacteria, and milk that has been much exposed to dirt contains many, low bacterial counts of milk at the farm have been widely accepted in the United States as a guarantee of the use of cleanly methods by the dairyman.

Bacteria decompose milk; sterile milk will keep indefinitely, but milk that contains many bacteria rapidly disintegrates at ordinary temperatures. Normally, clean milk has a pleasant flavor and odor but dirty milk is apt to be disagreeable either from dung which imparts a "cowy" taste or from products of bacterial decomposition which are often disgusting to the palate and foul-smelling. Dirty milk is frequently unsuited to manufacturing of dairy products because of the bacteria that it contains. While clean milk cannot be said to be safe milk in the sense that it is necessarily free from disease germs, it is probably true that the cleanly dairyman takes more pains to protect his milk, so far as he can, from infection than the dirty one does. In the words of the late G. M. Whitaker "dirty milk ought not to be considered a merchantable article at any price no matter how low."

The householder objects to dirty milk for several reasons. In the first place, dirt in the milk bottle serves warning that a food product which is in constant use in the home is being handled carelessly. In the second, dirt is offensive to the senses; milk that looks dirty, that smells bad or that is off flavor, is not relished. In the third, there is a firmly gounded conviction among most people that decency demands scrupulous cleanliness in the handling and preparation of food and this feeling is outraged by the presence of dirt in milk. Finally, the belief is entertained that dirty milk causes intestinal disturbances in children, particularly among those under 2 years of age, and many adults fearing the effect of such milk on their own health, forego its use.

**Milk of Extra Quality More Expensive to Produce.**—Large city milk dealers and manufacturers of dairy products pass on the milk their patrons bring them and often establish a scale of prices based on fat content, cleanliness, bacterial count or other considerations, but citizens in general have delegated to boards of health the duty of judging the quality of milk and of determining the safeguards that shall surround its production. So, to many dairyman the production of sanitary milk means little more than working under conditions imposed by these boards. While such a view is natural it is not the most helpful one. Sanitation as applied to dairying should be regarded first, as safeguarding the business with precautions that reduce the losses of producer and consumer from disease and second, as tending to secure successful marketing. The attainment of these objects costs money so that the dairyman is limited in his efforts to secure them by the willingness of his customers to pay enough for safe and superior milk to warrant its production. Most farm products give visible evidence of their quality so that the public is willing and expects to pay high prices for extra-fine meats, grains, fruits and flowers and they are graded in the market as firsts, seconds, etc. With milk and to some extent with its products this is not the case. It may be possible for the discriminating buyer to tell the best from the poorest, but to distinguish

between intermediate grades is impossible; so consumers are prone to think that all milk is the same and to be loth to pay more for one dairyman's than for another's.

So, while those who have the best interests of dairying at heart fully realize that milk should be produced in a sanitary way, they are keenly alive to the fact that the cost of doing so must be kept at minimum. They are compelled to demand that the protective regulations imposed on the industry by those who are chiefly interested in having the consumer supplied with wholesome uninfected milk shall be such as really accomplish this purpose, and that they shall not be of such a character as to add materially to the expense of producing and marketing milk, without actually furnishing an equivalent of additional protection. Rational dairy sanitation is not to be secured by adopting preventive measures against every conceivable source of pollution, but by first determining the sources of contamination and infection, and then proceeding to eliminate the important ones.

**Sources of Contamination.**—Observation and experiment point out many sources of contamination. As yet opinion as to their relative importance is formed on common sense and on the studies of competent men whose experiments have of necessity been conducted in a somewhat desultory manner. More comprehensive work is under way and no doubt will be helpful in confirming some of our opinions and in modifying others.

The sources of contamination are:

1. The cow
   - The udder.
   - Fecal and urinary discharges.
   - Buccal and nasal discharges.
   - Matter from the coat—Hair, skin, plants, barnyard.
2. Immediate environment
   - Air, ceiling, ledges, floor, etc.
   - Feed
   - Bedding
     - Mouldy hay, muddy hay, smutty straw, horse manure and sand.
     - *vs.*
     - Shavings, corn stalks, sawdust, peat, moss, cocoa shells.
   - Utensils
     - Pails, strainers, separators, clarifiers coolers, piping, bottles, cloths.
   - Water and ice.
3. Man
   - Buccal, aural and nasal discharges.
   - Anal and urinary discharges.
   - Skin.
   - Clothes.
4. Domestic animals, vermin and flies.

**Bacteria Derived from the Udder.**—Lister, according to Harding and Wilson, made the first observations on the bacterial content of milk from the udder and upon the results of his determinations on two small samples, came the belief that milk within the healthy udder is germ-free. Work by Lehmann and his pupil Schulz, in 1890, showed that fore-milk contained many bacteria, middle-milk fewer and the strippings still less. In this country Moore confirmed these results. He and his pupil Ward made examinations of excised tissue from different parts of functioning udders of freshly slaughtered milch cows and were able to demonstrate bacteria in the finer ramifications of the milk canal as well as in other parts of the udder. At another time they showed that the organisms which gave rise to gas and taint in a cheese curd originated in the udder. The bacteria work their way from the outside, up the teat canal into the milk cistern and thence into the milk canals. It is also possible but unusual for bacteria to find their way into the milk within the udder from the blood of the cow.

Bergey of the University of Pennsylvania, in the summer of 1903, studied the number and nature of bacteria in milk as it comes from the udder. Two hundred and seventy-two samples were examined and the bacteria found varied from 0 to 93,100 per cubic centimeter. Of the entire number of samples collected directly from the udder 87, or 32 per cent., contained no bacteria; 118, or 43.64 per cent., contained less than 500 bacteria per cubic centimeter and 28, or 10.29 per cent., contained over 5,000 bacteria per cubic centimeter.

He also examined the milk from each of the four quarters of 20 cows and obtained results such as those in Table 40.

Table 40.—Bacterial Content of Milk from Four Quarters of Cows (Bergey)

| Cow | Quarter of the udder | Bacteria per cubic centimeter |
|---|---|---|
| 9 | Right fore | 75 |
| | Left fore | 0 |
| | Right hind | 0 |
| | Left hind | 0 |
| 6 | Right fore | 75 |
| | Left fore | 25 |
| | Right hind | 150 |
| | Left hind | 25 |
| | Right fore | 3,400 |
| 14 | Left fore | 7,425 |
| | Right hind | 4,200 |
| | Left hind | 1,900 |

TABLE 40.—BACTERIAL CONTENT OF MILK FROM FOUR QUARTERS OF COWS (BERGEY) —(*Continued*)

| Cow | Quarter of the udder | Bacteria per cubic centimeter |
|---|---|---|
| 19 | Right fore | 14,100 |
| | Left fore | 8,400 |
| | Right hind | 3,150 |
| | Left hind | 1,850 |
| 5 | Right fore | 16,300 |
| | Left fore | 575 |
| | Right hind | 1,250 |
| | Left hind | 53,450 |
| 20 | Right fore | 250 |
| | Left fore | 850 |
| | Right hind | 175 |
| | Left hind | 44,300 |

The common occurrence of streptococci in milk attracted Bergey's attention and he pointed out that in many instances there was present in one or more quarters of the udder some evidence that the cow had suffered from mammitis. In other cases the udder was uninjured and there was no history of the disease, but he suggested that the attack may have been so mild as to escape notice, or that it may have occurred so long ago as to have been forgotten.

On account of the danger to be apprehended from contagious mammitis, the prompt removal of cows suffering with garget from the herd was advised, and warning was given that these sick cattle should not be milked or otherwise cared for by the attendants of the milking herd. The practice of milking the fore-milk onto the stable floor, Bergey condemned because of the likelihood of its spreading infection.

Hastings and Hoffman studied the bacterial content of milk from the udders of individual cows. The result of their observations on two that gave high counts and one that gave low ones are presented in Table 41.

TABLE 41.—BACTERIAL COUNT OF THE MILK FROM THE UDDER OF THREE COWS (HASTINGS AND HOFFMAN)

| Cow | Days sampled | Average number bacteria per cubic centimeter | Maximum number of bacteria per cubic centimeter | Minimum number of bacteria per cubic centimeter | Number of samples running over 1,000 bacteria per cubic centimeter |
|---|---|---|---|---|---|
| Brownie.... | 61 | 31,000 | 305,000 | 1,700 | 50 |
| Dorine..... | 33 | 191,000 | 3,500,000 | 2,500 | 28 |
| Merney.... | 27 | 810 | 4,250 | 50 | 0 |

In the case of Brownie and Dorine the high number of bacteria was due largely to the presence of a single kind of organism, a streptococcus similar to, or identical with *St. pyogenes*. In the case of Merney the bac-

teria were almost entirely yellow and white cocci. It was the opinion of the authors that the average bacterial content of milk from the udders of healthy cows is not over 1,000 bacteria per cubic centimeter; they figure that the presence of one Dorine in a herd of 16 cows would treble the bacterial count and they suggest that the removal of such a cow from a herd producing certified milk might be desirable.

Harding and Wilson studied the bacterial flora of cows' udders; their discussion of the topic is based on the quantitative relationships of 1,274 samples representing 83 cows and on the qualitative findings from 900 samples representing 63 cows. They found that many forms that occur in the udder are so accustomed to relatively high temperatures that they do not develop well on culture media at room temperature.

There are most bacteria in the fore-milk; in the main portion of the milking there are distinctly less, while the milk of the strippings contains an intermediate quantity and in fact shows numbers closely approximate to the germ content of the entire flow of milk. Samples of the strippings are very satisfactory for studying the udder flora.

An examination of 1,230 samples from 78 cows averaged 428 bacteria per cubic centimeter. There were about three times as many bacteria in the fore as in the hind quarters; the factor controlling this distribution was not found. Only about 8 per cent. of the samples examined had more than 1,000 germs per cubic centimeter and the authors concluded that the average germ content in the milk which could be regarded as having been derived from the udder were 500 per cubic centimeter.

Neither the age of the cow nor the period of lactation exerted any decided influence upon the germ content of the milk of the udder.

When classified according to the system of the Society of American Bacteriologists the organisms found in about 900 samples fell into 71 groups. No organisms producing spores and no motile forms were found.

In contrast to the experience of Harding and Wilson in isolating but two streptococci from 63 cows is that of Sherman and Hastings who in the milk of 88 animals in four herds demonstrated streptococci in 38.6 per cent. of the samples. The animals in three of the herds were examined but once, while those of the fourth herd were tested several times. These authors say they are certain that if milk is to be condemned because of the presence of udder streptococci a very considerable portion of milk-producing animals would have to be removed from the herds.

The fact that streptococcic infections are very common should be borne in mind by health officers who are investigating epidemics of septic sore throat. That such epidemics may arise from streptococcic infections of the udder is true but there is not necessarily any relation between streptococci found in the udder and those isolated from patients having the disease. Proof of their identity is demanded.

The most illuminating study of the udder bacteria is that of Evans.

She examined the milk of five herds of cows stabled in modern clean barns; three herds were in the vicinity of Washington, D. C., and two supplied certified milk to Chicago. Special methods of isolating and studying the bacteria were developed. In all, 192 samples of milk from 161 cows were examined. The intention was to consider only cultures which were capable of multiplying in the udder and becoming localized there and so no attention was given to types which occurred in small numbers. Altogether 32, or 16.1 per cent., of the 192 samples were from quarters of the udder in which the bacteria were not multiplying in numbers worth considering. Three types of microbes, viz., streptococci, staphylococci and bacteria were found.

In studying the streptococci a most important distinction was made between two groups, namely: (1) the long-chained streptococci which curdle litmus milk and partially decolorize it thereafter; and (2) *St. lacticus* which, prior to curdling, produces complete decolorization beneath a pink layer. *St. lacticus* was not found in any of the samples of milk which indicates that it does not localize and multiply in the udder. The long-chained streptococci were isolated from 29, or 15.1 per cent., of the whole number of samples. The highest number found per cubic centimeter was 264,000.

The micrococci were the most frequent components of the udder flora; they were found in 113, or 58.8 per cent., of the whole number of samples, the highest number per cubic centimeter being 80,000. The majority of the micrococci belonged to a single group which agrees with the pyogenic staphylococci. The majority of the cultures of this group were non-virulent but two were highly virulent to rabbits. To a second group no name was given because of the small numbers of cultures studied. A third group was identified with *M. luteus*. A fourth group was characterized by rapid and complete peptonization of the milk; hence it was named *M. caseolyticus*.

Bacteria of peculiar strains of types commonly present in freshly drawn milk, were sometimes found localized in the udder of several cows of one dairy and a few cases were found of peculiar species, unlike any of the udder organisms, being localized in the udders of several cows of one dairy. The Bacilli commonly present in milk from all dairies were shown to be related to *Bact. abortus*. Three varieties of this type were distinguished. The variety of *Bact. abortus* occurring most frequently in the samples of milk was designated *Bact. abortus, var. lipolyticus* because it decomposes butterfat; it agrees closely in its culture characteristics with Bang's original description, of *Bact. abortus*. Cultures of this variety were shown to be capable of imparting undesirable flavors and odors to cream kept under conditions such as those to which it often is subjected. Other varieties of the *Bact. abortus* type differed considerably from the lipolyticus variety but resembled cultures isolated from pathogenic

sources. Cultures of the *Bact. abortus* type were isolated from 45, or 23.4 per cent., of the 192 samples of milk studied; the highest number found per cubic centimeter was 50,000.

From the study Evans concluded that there is a definite udder flora comprising bacteria which belong to the parasitic type. She remarks that it is not surprising to find the organisms of the same type as those common on the skin and mucous membranes of man and animals. The majority of the organisms on the skin are non-pathogenic but there are some virulent forms and similarly the majority of those in the udder appear to be harmless but organisms virulent to the lower animals were isolated. While the pathogenic properties of the organisms from the udder are not discussed in this paper as a whole the data presented constitute a valid argument for the pasteurization of all milk.

Besides harmless microbes, milk from the udder at times contains the germs of disease. Cows with tuberculous udders secrete milk that contains large numbers of tubercle bacilli that are infectious to both humans and calves. Cows sick with anthrax yield milk containing anthrax bacilli and the milk of cows with the trembles has often proved fatal to those who have partaken of it. Barber's proof that a staphylococcus isolated in the milk fresh from the udder of a cow was the cause of many cases of gastro-enteritis shows that organisms that are not recognized as disease germs may at times cause severe sickness.

**Fecal Contamination of Milk.**—The fecal and urinary discharges of cows for the sake of decency should be kept out of milk; the very idea of their presence is abhorrent. Both may be the cause of disease; it is known that they may transmit tuberculosis and other maladies, particularly the intestinal disturbances of infants and less frequently of adults, are attributed to the use of milk heavily polluted with animal excrement though the specific exciting organisms may not be known. Of course cows are constantly defecating and urinating and some of the matter passed adheres to the coat and will fall into the milk unless cleanly methods of milking are used. Bacteria of the *B. coli-Bact. lactis aerogenes* group occur abundantly in feces. They are likely to form a gassy curd and also to produce an offensive odor and a disagreeable taste in milk and in cream soured by their action, consequently they impair milk for cheese making and for the city milk trade and cream also for use in manufacturing butter. So both to protect the public health and for strictly commercial reasons everything should be done to check fecal contamination of milk.

**Contamination of Milk by Discharges from the Nose and Mouth.**—The nasal and buccal discharges of cattle are the source of bacterial contamination of milk. *St. lacticus,* which is the cause of ordinary milk souring, Esten has pointed out is always present in large numbers in the cow's mouth, consequently in licking herself she transfers them to her

coat from which they find their way into the milk. These germs are beneficial to the dairy industry because they cause milk to decompose in the normal way and because they play a necessary part in the manufacture of butter and other dairy products, but there are also in the droolings and nasal discharges of cows sick with certain diseases germs that may infect man, consequently the possibility of their causing trouble should be borne in mind.

**Contamination of Milk from the Coat of the Cow.**—The cow is a neat animal and when she is out of doors, unless she is pastured on marshy lands or kept in an undrained barnyard, the wind and rain keep her coat clean but if she is confined in the barn she will get very dirty unless carefully cared for. The dirt that collects on her coat is made up of fecal matter, dust from the hay and all sorts of substances with which she comes into contact. It dries on the hairs of her coat and is readily dislodged. Pains must be taken to prevent this dirt falling into the milk during milking. This is best accomplished by keeping the cow as clean as possible; she should be curried long enough before milking to give the dust time to settle. Then she should be tied in such a way that she cannot lie down until after milking is done. Currying of the cow and wiping her udder may be made easier by clipping her belly, udder and hind quarters. Before milking is begun the udder should be washed in lukewarm water and then partially dried with a clean cloth. This removes loose hairs, particles of skin and dirt that otherwise would fall from the udder as it is manipulated in milking. The washing and wiping of the udder should be done thoroughly. Care should be taken not to spread garget and other contagions in the herd by using cloths on other animals that have been used on sick ones. The bacteria that get into milk from the coat are of many sorts; the germs that are most undesirable are members of the *B. coli-Bact. lactis aerogenes* group which come from the manure and those of the *B. subtilis* group which come from the hay and dust. Members of the latter group decompose protein often with the production of vile odors; they sometimes cause the sweet curdling of milk, and according to Rosenau their presence in excessive numbers has often caused gastro-intestinal disturbances in children.

Wolf and Weighmann demonstrated that the bacteria on the leaves of certain pasture plants were identical with those that occasionally affect milk injuriously so that they, and also Ernst, believe that cows in pasture, at times infect their coats with bacteria from plants, with the result that when the cows are milked these bacteria get into the milk and cause unpleasant flavors.

**Small-top Milk Pails.**—To reduce the numbers of bacteria that get into milk from the coats of animals and from other sources in milking, small-top milk pails should be used. The first that were introduced were badly designed, or were fussy contraptions that met with little

favor but these pails have been simplified and made practical so that there can be no reasonable objection to their use.

According to Harding, Wilson and Smith, Dr. R. G. Freeman was the first to see the advantages of the small-top pail. He tried to introduce it at the Fairfield Dairy in 1895 but without success. It was seen in use there by S. M. Shoemaker who adopted it in his Burnside Dairy at Eccleston, Md. The Freeman pail was difficult to use and to clean so that it was never popular. The Gurler pail which was brought out by H. B. Gurler of De Kalb, Ill., about 1895, was more successful. The Stadmuller pail made by F. H. Stadmuller of West Hartford, Conn., was the next to attract attention; for some time it was in daily use in the Storrs Agricultural Experiment Station. A host of small-top pails, some of them highly impractical, followed. Among the patterns that survived are the Storrs pail designed by J. M. Trueman of the Storrs Agricultural Experiment Station, the Amherst pail and the improved Loy pail made by Harry Loy of Geneva, N. Y. A pail that has met with considerable favor because of its convenience for the milker is the Cleano, made by C. E. Tyler of Rome, N. Y.

The milk hod seems to have been invented at Shoemaker's Burnside Dairy, where it is in use, and modifications of it by Charles E. North and by Stephen Francisco, Jr., have been brought out as the North and as the Francisco milk hods.

Some bacteriological studies of the value of small-top milk pails were made by Freeman and by Conn but the first extensive experiments were those of Stocking in 1901. They indicated the great value of such pails and led to the doing away with the strainers that were a part of the pails then in use, for it was shown that the dirt that lodged on them was beaten up and forced through them into the milk by the streams of milk from the teat. Stocking continued his studies, experimenting with the Stadmuller, Haymaker, North and Gurler pails and in *Bulletin* 48 of the Storrs Experiment Station summarized the results of his work. Among other things he concluded that the small-top pail excludes much dirt and many bacteria from milk, that the shape of the pail and of the top is not important provided the pail is convenient to use and has a top with an opening as small as may be without making milking difficult.

Harding, Wilson and Smith in 1910 published the results of their studies on the small-top pail. They experimented with eight different pails with small tops, and reached the conclusion that the pails should not be over 12 in. high and should have elliptical rather than round openings, because that shape is easier to milk into and may be smaller than a round one, an opening 5 by 7 in. sufficing. The cover should be flush with the top of the pail in order to avoid a groove that will lead dirt from the top into the milk and should be convex that the pail may be easily cleaned. They found that more than half the contamination milk

receives at milking can be prevented by the use of the small-top pail. A defect in many of the covered pails is the lack of a ridge around the opening to prevent dirt rolling from the top of the pail into the milk.

**Milking Machines.**—The drudgery of milking has deterred many a farmer from entering dairying and the increasing cost of farm labor has made employers anxious to economize in its employment. So of recent years there has been much experimenting with milking machines. As early as 1819 inventors were endeavoring to produce a successful mechanical milker but it was not till the appearance of the Lawrence-Kennedy machine in 1902 that a measurably successful one was produced. Since that time advance has been rapid and at the present time there are several milkers on the American market; among them are the Burrell-Lawrence-Kennedy or B-L-K, the Sharples, the Calf-way and the Empire. Harding has pointed out that these and all other successful machines operate on the suction principle, imitating the calf which wraps its tongue around the teat, presses it slightly and forms a vacuum thereby producing a suction which releases the sphincter muscle of the teat and withdraws the milk. The calf does not suck steadily but gives about 40 sucks a minute so that the application of the vacuum is intermittent. In the early machines the vacuum was continuous and it was not till Shiels conceived the idea of admitting air to produce vacuum pulsations that encouraging results were obtained. This idea was perfected by Lawrence and Kennedy.

It has been the object of manufacturers to produce milkers of low first cost which should be economical and simple to operate, which would not injure the cows, which would milk so clean that it would be unnecessary to milk out the strippings by hand and which would deliver milk of low germ content. Varying degrees of success have attended the efforts to attain these results. With regard to the production of sanitary milk, the machines were at first a great disappointment but at the several experiment stations where they were installed for study showed that the principal sources of contamination were: (1) the air that was admitted to the teat cup; (2) the soiling of the cups by careless handling and dropping them on the floor; and (3) the rubber parts which were difficult to clean after milking.

The air contamination was easily prevented by filtering the air through cotton before admitting it to the cups. The contamination that results from dropping the cups can be avoided only by handling them carefully in the stable. The contamination from the imperfectly cleaned rubber parts was difficult to cope with. It was soon seen that the parts would not only have to be thoroughly washed but that they would have to be kept when not in use in some antiseptic solution. After considerable experimentation common salt, lime water and bleaching powder have been found suitable for the purpose. The common practice now is to

rinse out the cups and rubber connections in cold or tepid water after which they are thoroughly washed in a hot solution of washing powder and rinsed in clean water. Then they are kept in an antiseptic or a germicidal solution, preferably of chloride of lime or bleach. In putting the tubing into the antiseptic, great care must be taken that air pockets do not form and prevent the solution coming into contact with the rubber. When the rubber parts are needed they are carefully rinsed in clean fresh water before using them. The buckets into which the milk flows should be washed after milking and sterilized with steam before being used again.

An objection that has been raised to the use of milking machines is that if a high vacuum was inadvertently used the cellular content of the milk might be increased or that blood might be drawn from the udder. Breed has found these fears groundless but advises the use of the low vacuum recommended by the makers.

The point has been made that in machine milking incipient udder trouble is more likely to escape attention than in hand milking because the udder is handled less. This is most likely to happen where two cows are milked into a bucket having a single compartment for slight abnormality in the milk is apt to pass unnoticed. Also fear has been expressed that garget might be spread in the herd by the teat cups. In practice this does not seem to have been a serious matter.

A factor that has operated to impede the introduction of all types of milking machines is that, though they are not too complicated for intelligent dairymen to handle, far more mechanical ingenuity and dependability than the average dairy hand has, is required to operate them successfully; so it is necessary to employ a man who commands higher wages.

**Contamination of Milk in Straining.**—It seems to be the opinion of many dairymen that it matters little whether dirt gets into milk or not, because it can be strained out later. At all events, in many dairies a deal of time is spent straining milk. Of course it is known, since manure and other dirt that gets in milk is partially soluble, that all of it cannot be removed in this way but it is natural to think that the milk will be better for having the visible dirt strained out. Careful experimentation shows that no great amount of improvement is effected in this way. Conn, Stocking and many others have studied the matter and gotten results that are substantially the same.

Stocking determined the bacterial content of five samples of milk, passed them through three thicknesses of fine cheese cloth, supported on wire gauze and then determined the count of the filtered milk. The results which are those given in Table 42 are such as are obtained when milk is carefully filtered through cheese cloth into clean vessels, and the effect of filtering is therefore shown most favorably.

TABLE 42.—EFFECT ON THE BACTERIAL COUNT OF STRAINING MILK THROUGH CHEESE CLOTH (STOCKING)

| Samples | Number of bacteria per cubic centimeter before straining | Number of bacteria per cubic centimeter after straining |
|---|---|---|
| 1 | 3,600 | 3,600 |
| 2 | 7,400 | 6,900 |
| 3 | 12,800 | 10,500 |
| 4 | 8,800 | 11,375 |
| 5 | 8,000 | 2,200 |

Five other samples were filtered in the same way and the keeping power of the filtered and unfiltered portions compared, with the result that it was found that the keeping quality of none of the milk was improved by filtering and that of some was impaired. The use of strainer cloths on the farm probably has a bad effect, for they are commonly used again and again without being boiled out and dried quickly every time they are used; hence they seed the milk with bacteria. Moreover, when the filters clog, the milkers are prone to poke them and so contaminate the milk with their fingers.

**Influence of the Cream Separator on the Bacterial Count of Cream and Skim-milk.**—Milk can be skimmed and clarified by centrifugal force. On the farm, cream separators are used for skimming the milk and also to some extent for clarifying it. In city milk plants clarification is accomplished by specially designed centrifugal clarifiers.

By the use of cream separators the bacterial count of the milk is increased in two ways, namely: by the actual addition of more germs to the milk, by contact with the insterile parts of the separator through which it passes; and second, by the breaking up of bacterial clumps and chains as the milk passes through the machine. Of these two, the former is the more important when the cleaning of the separator is habitually slighted. The breaking up of the clusters and chains most noticeably increases the number of bacteria when the milk being separated or clarified has a high count. In the passage of the milk through the separator, part of the germs go with the cream, part with the skimmed milk, and part are thrown out with the slime. Apparently the percentage of bacteria that goes to each varies, for conflicting results have been obtained by different experimenters. Most find that after separation both the skim-milk and the cream contain more bacteria than did the original milk, and that the cream contains more than the skim-milk but that both contain fewer than the slime. Possibly a distribution after separation of 25 per cent. of the bacteria in the skim-milk, 28 per cent. in the cream, and 47 per cent. in the slime, is an approximation of what may be expected but no fixed ratio can be predicted. Heinemann, Luckhart and Hicks found fewer bacteria in the separated cream and

more in the skim-milk than in the unskimmed milk. Heinemann and Class continuing the experiment found that separated cream contains fewer bacteria than the milk from which it is obtained, that the number of bacteria in separated cream decreases proportionately as the fat content increases and that the number of bacteria in separated milk is larger than the number in the milk from which it is obtained, if the cream contains up to about 35 per cent. fat; above this percentage the number is smaller. They found, too, that the number of bacteria in separated milk decreases proportionately with increase of fat in separated cream.

**Cooling of Milk.**—It is absolutely essential in order to prevent rapid bacterial development in milk, with consequent deterioration thereof, that it be cooled promptly after milking. On most farms the cooling is done by setting the milk in a tub of well or ice water. The effectiveness of this method is shown by the figures in Table 43.

Table 43.—The Cooling of Cream in Cans (U. S Dept. of Agriculture)

| Method of cooling | Temperature of cooling medium | Temperature of cream | Temperature in degrees Fahrenheit of cream at later periods | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ½ hr. | 1 hr. | 2 hr. | 3 hr. | 4 hr. | 5 hr. | 6 hr. | 7 hr. | 8 hr. |
| Can of cream placed on cement floor in cellar.. | 62 | 92.5 | 90.5 | 89.0 | 87.0 | 87.0 | 85.0 | 80.5 | 79.0 | 78.0 | 76.5 |
| Can of cream placed in cool non-running water | 52 | 89.0 | 86.7 | 83.0 | 76.7 | 73.0 | 70.0 | 68.2 | 67.0 | 65.7 | 65.0 |
| Can of cream placed in cool running water.... | 52 | 86.5 | 83.8 | 75.6 | 65.1 | 62.5 | 60.5 | 59.0 | 58.0 | 57.0 | 56.1 |
| Can of cream placed in cool running water and stirred at half-hour intervals............... | 52 | 85.5 | 77.0 | 68.4 | 63.5 | 60.5 | 58.7 | 57.5 | 56.4 | 55.5 | 55.0 |

Many farmers instead of cooling milk in cans bring it to low temperature by running it over coolers. They are of various sorts but in all of them the milk is cooled by flowing in a film over an extensive surface of thin metal which is chilled by cold water or by brine. Coolers work well when properly cared for but they cannot be neglected without injury resulting to the milk for it flows over the entire surface of the cooler and consequently picks up all the dirt there is on it. Whenever steam is available coolers should be sterilized immediately before use. In watching the cooling of milk one sometimes sees it refuse to flow over a part of the cooler, which generally indicates that the spot is unclean. Milk may be both contaminated and adulterated by the escape of water or brine from a leaky cooler. Besides being contaminated by the cooler the milk may be also, by the air, if the cooler is an open one and the cooling is done in a dusty place. If the room is malodorous the milk may

acquire an off flavor; sometimes the operation of a gasolene engine where the cooling is being done will impart a distinct taste to the milk.

**Aeration of Milk.**—Formerly much store was set by aeration as a method of removing odors from milk and in improving its keeping quality but it is now known that milk from healthy cows which have been properly fed and that is drawn in a place free from stenches has no disagreeable smell. Furthermore such improved keeping quality as resulted from aeration is now attributed to the cooling of the milk in the process. So this fetish is not so fashionable among dairymen as it once was. Such aeration as milk now receives it generally gets in the process of cooling but that aeration of first-class milk is not necessary is shown by some of the best certified milk being bottled warm and cooled afterward. When warm milk is put into cans and the covers put on, it sometimes happens that bad flavors develop but this is believed to be due to bacterial growths that are favored under such conditions because the milk has not been properly cooled rather than because the milk was not aerated.

Sometimes milk may be improved by aeration. Ayres and Johnson have pointed out that the garlic flavor so common in milk in some localities where the animals eat the wild onion in pasture, may be removed from milk and cream by heating them to 145°F. and blowing air through under pressure.

**Barn Practices in Relation to Milk Quality.**—The attempt has been made to estimate the relative importance of the common barn practices in contaminating milk. Stocking in *Bulletin* 42 of the Storrs Agricultural Experiment Station published observations on the effect at milking, of feeding cows, of brushing them, of wiping them with a damp cloth, of rejecting the fore-milk and of trained as compared with untrained milkers. The results of his study are presented in Table 44.

TABLE 44.—THE EFFECT ON THE BACTERIAL COUNT, OF FEEDING, OF BRUSHING, OF WIPING COWS, AND OF REJECTING FORE-MILK AT MILKING (STOCKING)

| | Total number of bacteria per cubic centimeter | Acid forming bacteria per cubic centimeter | Liquefying bacteria per cubic centimeter |
|---|---|---|---|
| Average 6 experiments, before feeding hay and grain | 2,096 | 790 | 108 |
| Average 6 experiments, after feeding hay and grain | 3,506 | 1,320 | 196 |
| Percentage of increase due to feeding | 67.0 | 67.0 | 81.0 |
| Average 5 experiments, before feeding dry corn stover | 1,233 | 297 | 1 |
| Average 5 experiments, after feeding dry corn stover | 3,656 | 692 | 28 |
| Percentage of increase due to feeding | 196.0 | 133.0 | .. |
| Average 14 experiments, cows not brushed before feeding | 1,207 | 213 | 59 |
| Average 14 experiments, cows brushed before feeding | 2,286 | 381 | 117 |
| Percentage of increase due to brushing | 89.0 | 79.0 | 98.0 |
| Average 13 experiments, cows' udders and flanks not wiped | 7,058 | 3,554 | 81 |
| Average 13 experiments, cows' udders and flanks wiped | 716 | 185 | 47 |
| Percentage of decrease due to wiping | 89.8 | 94.7 | 42.0 |
| Average 8 experiments, fore-milk not rejected | 522 | 189 | 9 |
| Average 8 experiments, fore-milk rejected | 499 | 99 | 33 |
| Percentage of decrease due to rejection of fore-milk | 4.4 | 47.0 | |

It thus appears that feeding dry and dusty feeds at milking time increases the bacterial count materially as does brushing the cows, and that wiping the cows udders and flanks decidedly reduces the count. Rejecting the fore-milk has little effect. Experiments showed that in order to exclude the fore-milk of high germ content it would be necessary to waste at least six good-sized streams from each quarter, an amount that means considerable loss. Also, it was shown that a student who had some bacteriological training could milk so as to get a markedly lower count than the regular milkers who lacked this training.

**Sterilizing and Protecting the Pails.**—Harding, Rhuele, Wilson and Smith studied the effect upon the germ content of milk of: (1) protecting milk pails by tying cloths over their tops before sterilizing them, and not removing the cloths till milking was actually begun; (2) of the effect of plastering, of painting and of whitewashing the stable; (3) of clipping the cows; and (4) of hand- and machine-cleaning of cows.

In the experiment on the effect of keeping the pails covered, tests were made on 6 days, four cows being used. The tests were so conducted that two of the cows were milked into pails that had been sterilized and kept covered till milking was begun and two were milked into sterilized pails that were brought into the barn uncovered with the other utensils, while on the following day the two cows that had been milked into the pails that had been kept covered were milked into those that were not covered and the other cows were milked into those that had been covered over. No pails were used more than once at a milking. At every milking, samples were taken from each pail and plated. So, in the series from each cow there were three samples from the protected and three from the unprotected pail or 24 samples altogether. The results show an average count of 922 bacteria per cubic centimeter, in the samples from the protected pails, and 2,391 on those from the unprotected, or an increase of 160 per cent. due to exposure. The authors regard this as important though they point out that the influence of this initial contamination would have been much less had succeeding cows been milked into the same pail.

**Plastering, Painting and Whitewashing.**—The authors studied the relationship of plastering, painting and whitewashing to the bacterial count in a series of experiments at the stable of the New York Experiment Station which had a ceiling of beaded, planed, matched southern pine, and walls finished in the same material. This construction is not used in modern barns because dust accumulates in cracks between the boards and in the beading. Dust was allowed to collect on walls, ledges, and stanchions until conditions were as bad as would be tolerated under reasonably good barn management. In this state the germ content of the milk of each of six cows was determined at six separate milkings. When this study was completed the ceiling and walls of the stable were

covered with wire lath and two coats of cement down to within 3 ft. of the floor; the area between the cement and the floor was covered with zinc. In putting the barn in order after plastering, the stanchions, floors and mangers were thoroughly cleaned. Then milk from the same six cows was tested again on 6 days, every effort being made to keep the barn management and bacteriological examination identical to that which obtained in the unplastered barn except that in this series of tests no dust was permitted to accumulate. Next, the woodwork and ironwork of the stable were painted and a series of six tests with the same six cows was run under these conditions. A summary of the counts obtained are shown in Table 45.

TABLE 45.—AVERAGE GERM CONTENT OF MILK UNDER VARIOUS BARN CONDITIONS (HARDING, WILSON, RUEHLE AND SMITH)

| Cow | Before plastering | | | After plastering | | | After painting | | |
|---|---|---|---|---|---|---|---|---|---|
| | Whole milk | Strippings | Difference | Whole milk | Strippings | Difference | Whole milk | Strippings | Difference |
| Millie F. | 2,271 | 262 | 2,009 | 1,741 | 245 | 1,496 | 906 | 139 | 766 |
| Nora D. | 774 | 321 | 462 | 1,298 | 436 | 861 | 1,234 | 220 | 1,014 |
| Millie F. B. B. | 293 | 112 | 181 | 176 | 17 | 159 | 83 | 11 | 72 |
| Chloe B. | 370 | 93 | 227 | 337 | 94 | 243 | 448 | 184 | 303 |
| Carey S. F. | 468 | 119 | 348 | 561 | 108 | 452 | 265 | 77 | 188 |
| Mabel S. F. | 475 | 178 | 298 | 1,164 | 570 | 594 | 899 | 535 | 364 |
| Genl. average | 775 | 179 | 596 | 889 | 249 | 640 | 656 | 198 | 459 |

The table needs little explanation further than to state that the figures in the columns headed difference are obtained by deducting from the bacteria in the whole milk the bacteria in the strippings, it having been found by the authors that the bacteria in the strippings fairly represent the number of bacteria in the udder.

In commenting on the results from the 212 samples the authors point out that they show that in the last two sets of tests when the barn was clean, the difference in germ content of the milk was greater than the difference between the results when the barn was clean and when it was dirty. The gist of the matter is that the influence of these barn conditions upon the germ content of the milk was so slight that it was immeasurable.

About a year after the station barn was plastered a series of tests was made to determine the effect of the whitewashing of a barn on the bacterial count of milk produced in it; the experiments were suggested by an ordinance that is found in many health codes requiring dairy barns to be whitewashed once a year or oftener. For 20 successive days the milk of each of three cows was sampled and plated. Comparison of the results shows that the general average of the 60 samples taken after white-

washing was a trifle higher than the 60 taken before but the difference is not great and as a whole they show that whitewashing the stable neither raises nor lowers the bacterial count of the milk.

**Clipping the Cow's Udders and Flanks.**—The effect of clipping the cow's udders and flanks was studied and the results obtained are presented in Table 46.

TABLE 46.—SUMMARY OF BACTERIAL COUNTS, EXPRESSED IN NUMBER PER C.C. OF MILK DRAWN FROM UNCLIPPED AS COMPARED WITH CLIPPED COWS

| | Carey S. F. | | | Gertie F.I.B.B. | | | Millie F.B.B. | | | Carey S.B.B. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Whole milk | Strp-pings | Dif-ference | Whole milk | Strip-pings | Dif-ference | Whole milk | Strip-ping | Dif-ference | Whole milk | Strip-pings | Dif-ference |
| Unclipped (ave. 22 samples) on each cow | 158 | 82 | 76 | 320 | 81 | 239 | 142 | 75 | 67 | 196 | 46 | 150 |
| Clipped (ave. 24 samples) on each cow. . | 252 | 145 | 107 | 470 | 92 | 378 | 261 | 73 | 188 | 298 | 138 | 160 |

The grand average of all the samples shows that the unclipped cows had 204 bacteria per cubic centimeter in the whole milk, 71 in the strippings and as difference 133 whereas the clipped cows had 320 in the whole milk, 112 in the strippings and as difference 208, thus showing higher counts in the milk of the clipped cows. Moreover, Table 46 shows that in every instance the count of the milk of the four cows was higher when they were clipped than when they were unclipped. In explanation of this unlooked for result the experimenters suggest that the long hairs retain the scurf at their base while the short ones do so less effectively so that it falls into the milk and increases the bacterial count.

**Hand- vs. Machine-cleaning of Cows.**—The same authors compared the cleaning of cows by hand with cleaning them by a vacuum cleaner and found that the latter method was less efficient than the former when the vacuum was less than 15 in., and in any case is more expensive since it takes about twice as long.

**Interpretation of the New York Station Experiments.**—These studies of Harding and his confreres are important because long periods of continuous sampling were employed so that every series of tests is a fair measure of the process under investigation under the conditions that obtained. Nevertheless, it seems likely that those who read the bulletin which contains the results may draw differing conclusions from them. To the writer it seems that these experimenters have shown that in a barn of fair construction where the help is accustomed to pay decent regard to cleanliness, clean milk may be drawn even when the barn is dirty and when the construction is such as would not be recommended were the owners building anew. They also show that plastering, painting and whitewashing do not directly influence the bacterial count. The results are confirmatory of what has long been suspected. Many dairy men are known to produce excellent milk in barns that seem un-

suited for them to do so. The question then arises why plastered and painted barns have superseded those of matched boards and why health authorities advise whitewashing. Speaking by and large, dirty barns and good dairying have parted company forever; barns of matched boards, with age, become dingy, more difficult to clean and give trouble from the boards separating. The plaster finish appeals to the practical man as being lighter, brighter and more easily cared for. Then, there is this difference between the two types, the wooden barns absorb odors so that neglect of cleanliness, or even long use, tends to give them a decided odor that is likely to be unpleasant, and one that is apt to be acquired by the milk, but plaster work tends to neutralize odors rather than to store them. It is to keep the barn sweet as well as for appearance that the woodwork in barns is painted. Whitewashing is insisted on by boards of health, chiefly in old wooden barns as a means of lighting them up, so that better work will be done in them, because the light reflected from the white walls helps one to see. Also, probably whitewashing helps to keep down vermin but it is chiefly useful in filling the pores of the wood thereby preventing the absorption of odors and making the barns better smelling. Putting these things together it seems that the experiments fortify inspectors with reasons for permitting men of small capital and those serving a class of trade than cannot afford luxuries, to continue in business with mediocre equipment provided they are actually producing good milk, but where the diligence to succeed under such conditions is lacking there are ample reasons for requiring the plant to be improved or business stopped. Similar experiments are desirable to determine if possible what degree of dirtiness must obtain in the dairy barn to raise the bacterial count.

The writer regards as interesting the fact that the scurf from clipped cows was found to raise the count above that of the milk of the carefully cleaned, unclipped ones but he believes that in practice cows will continue to be clipped because in that condition they are easier to clean and consequently will be more thoroughly cleaned than they would be were they left with long-haired udders and flanks.

**The Open Stable and the Germ Content of Milk.**—In the States of the Union that have a mild winter there are in use open stables for housing cattle. There is a tendency for the germ content of the air of closed cow stables to be higher in winter than summer, because of the closer confinement of the cows and the use of dry feeds and bedding that fill the air with more or less dust. So it seems that milk drawn in the separate milking room of an open stable might contain fewer bacteria than that drawn in a closed stable. A brief series of experiments to determine the matter was conducted by Lamson at the Maryland Agricultural Experiment Station. While his data were too limited to permit him to draw definite conclusions, they indicated that the germ content

of the air of the milking room of the open stable, was less than that of the closed barn; that fecal contamination of the milk from cows kept in the open stable, where the cows receive little attention, was no greater than in closed stables, where they receive a good deal, and that there is advantage in the open stable as a place to produce milk of low germ content.

Milk is polluted by bacteria derived from dust and from many sources in the immediate environment of the stable and other places where it is handled most. Among these sources of pollution are the air, the feed, the bedding, utensils of various sorts and the milkers.

**Air-borne Contamination.**—The belief in air-borne diseases has been held for many centuries and from the early days of bacteriology until very recently air was believed to be an important factor in transmitting contagion, but more complete understanding of microbial life has shown that while germs do float in the air, air-borne infection is not to be greatly dreaded. There is of course a great difference in air as to the germ content; some is very dusty and carries many bacteria while other air is very clean and nearly germ-free. It may be advisable to filter or wash the air that comes into a milk plant located on a dusty city street, but wholly unnecessary to, that of one in the country. Also, some dust may be rather heavily polluted with animal excretions while other may be only slightly so. In any case it is the visible and invisible dirt that floats in the air which is the cause of bacterial contamination and not the air itself, for the germs are attached to dust particles, though not to all of them for some, as for instance those of soot, are sterile and all the motes that float in the air tend to become so by drying and the germicidal action of sunlight.

At the New York Experiment Station Rhuele and Kulp have made a careful quantitative study of how the germ content of the stable air affects milk. As a whole their results show that the microbial contamination that milk derives from standing in the air of a well-kept barn is unimportant. Out of 54 tests in the station barn there were but 17 that showed the number of precipitating bacteria to be greater than 100 per square centimeter in a 5-min. interval, and the highest of these was only 269 per square centimeter. Many of these tests were made when the barn air was disturbed by the feeding of silage, the brushing of cows, etc. Even during the worst of these conditions, an open pail of milk could have stood 15 min. in the stable without a detectable increase in the bacterial content of the milk occurring.

A brief exposure of the milk to the very dusty atmosphere that prevailed for short intervals, during certain barn operations in commercial dairy barns was sufficient to appreciably raise the bacterial content of the milk and such conditions should be guarded against.

The experiments indicate that bacterial contamination of milk from

the air of stables is much less important than has been thought and that a reasonable amount of care in avoiding extremely dusty operations during milking will suffice to protect the milk adequately.

Thus the quantitative microbial pollution of milk by stable air is fairly well understood but there is little known about the relative importance of the germs of different groups in the air-borne contamination that does occur. Bacteria yeasts and moulds are all found in stable air. Among the bacteria certain micrococci are common and so are

*Courtesy of J. O. Jordan.*

FIG. 30.—New England barn of the type in which the air is seriously contaminated in feeding the hay.

organisms of the *B. subtilis* group. Bacteria of the *B. coli-Bact. lactis aerogenes* group may be swept into the air with particles of dung and from other sources. Disease germs are uncommon in the air but to some extent *Bact. tuberculosis* and other pathogens may circulate in the air in infected stable dust. In a goat stable, if there are animals which have been imported from Mediterranean countries, the dust is likely to be infected with *M. melitensis*. Mould spores are common in stable air but yeast is less so than are either bacteria or moulds.

**Contamination from Feeds.**—Feeds of various sorts are often rich in bacteria that become attached to the leaves or kernels of grain of the

growing plants or are derived from the soil or else from human sources in the course of garnering or manufacturing. Organisms of the *B. subtilis* group, of the butyric acid group, and of the *B. coli-Bact. aerogenes* group, all have been found abundantly in feeds. It has been noted that condensed milk is sometimes spoiled by gassy fermentations produced by spore-bearing organisms and that this trouble is most likely to occur in the autumn when crops are being put into the barn and the stable air is filled with dust.

**Contamination from Bedding.**—Bedding is the source of many kinds of bacteria and of moulds, among the former, those of the *B. coli-Bact. lactis aerogenes*, the *B. subtilis* and the butyric acid groups may be mentioned. Clean bedding such as shavings, sawdust, peat moss, cocoa shells, etc., gives little trouble but dusty, smutty or mouldy bedding and a litter of fallen leaves, horse manure or of sand all are likely to produce ill effects on the milk. One of the worst litters from the point of view of bacterial contamination that the author ever had to deal with was a coarse hay that was cut on a meadow subject to periodical overflow by a muddy river. Brainerd, at the Virginia Agricultural Experiment Station, made a short series of experiments in the Station stable to determine the source of bacteria in the milk produced there. Among other things he found that when bright clean straw was used as a litter the bacterial content of the milk could be decidedly reduced by moistening the straw before milking, and that with sawdust for a litter as good bacterial results were obtained as with moistened straw.

**Contamination from Dairy Utensils.**—Dairy utensils have been pointed out by several bacteriologists as a fertile and serious source of milk contamination. The trouble comes about in this way: a little milk containing bacteria or their spores is left adherent to the vessels in the form of inconspicuous drops, or an invisible film or ever so slightly milky water that condenses at the time of scalding or steaming. These microbes establish themselves on the utensils and may multiply on them; in either case, they germinate in the milk that is next put in. Hasty, careless cleaning is partly to blame for this sort of pollution but it is also partly due to faulty construction of the utensils, to washing being done in the wrong way and to scalding or sterilizing being neglected.

All utensils should be made with as few seams as possible and the necessary ones should be flushed with solder so that there will be no crevices in which milk can accumulate and be decomposed by bacteria. So far as practicable, utensils that are inconvenient to clean should be discarded; certain covered milk pails and cream separators are of this sort.

New tinware is easily kept clean but that which is rusted and that which by rough usage has had the tin plate knocked off cannot be cleaned so that there will not be large numbers of germs in the spots and crannies

where rust shows. Badly rusted and dented tinware is properly confiscated by boards of health.

The trouble that the cleaner causes is in part due to his carelessness and in part to his doing the work in the wrong way. Vigorous prodding by some one in authority is the only cure for the shiftless washer. Proper cleansing of milk vessels is effected by first rinsing them in cold or lukewarm water to remove the milk after which they should be scrubbed with a brush inside and out, in hot water and washing powder; then they should be rinsed in clean hot water. If the cold rinse is omitted the hot water will cause some constituents of the milk to stick tenaciously to the utensils.

Sterilization of milk utensils is generally effected by heat. The effectiveness of the process depends on the degree of temperature and the length of time it is applied. The use of water at less than boiling temperature and hurrying the work unduly, makes the process a farce. The smaller vessels and bottles can be thoroughly sterilized by boiling them. The breakage of glassware need not be excessive if the bottles and other dishes are first put in tepid water which is afterward brought to a boil. Care should be taken to cool the glassware slowly, otherwise it is apt to become brittle. In many small dairies and in all large plants steam is available for sterilizing. It is used in several ways; it may be turned into cold water to raise the temperature, or in the form of streaming steam it may be played from a hose onto apparatus, or ejected from stationary jets into cans and other tinware or turned into chambers of various sorts containing utensils to be sterilized. Under pressure, steam is most effective as a sterilizing agent and in large milk plants there are huge sterilizing ovens for employing it in this way. There is no question of the effectiveness of steam for sterilizing, when it is faithfully and intelligently used. It gives a sense of security to see it freely employed for this purpose in a milk plant or factory, but this feeling is often unwarranted for very frequently the steam is not applied long enough to the utensils to more than raise the temperature to the point where bacterial multiplication is stimulated, or else it merely loosens the milk or bacterial coating adherent to the utensils so that the next milk that is put in them is heavily contaminated. Bacterial tests made some hours after cans have been steamed often show how imperfect sterilization has been and a foul odor indicative of bacterial decomposition is often plainly noticeable when covers are removed at the farm, from cans washed and steamed at the city milk plant or creamery. A device that will insure the exposure of the utensils to the action of the steam jets for a fixed length of time is needed. While with autoclaves, sterilizing is less likely to fail, the danger still exists for if they are run carelessly the pressure required to sterilize may not be reached.

When tinware is sterilized by streaming steam it should be dried

thoroughly; in large plants this is done by a hot-air blast. If one is not used, unless the utensils are carefully drained, milky puddles from the condensed steam collect in them and soon support rich bacterial growths. On the farm after scalding or boiling, utensils are usually wiped with a cloth; it should either be new, or one that has been boiled and dried quickly. Bacteria multiply in cloths so long as they are wet, and the good effect of boiling utensils is often entirely destroyed by wiping them afterward with a cloth that supports a rich growth of germs. Sunlight has a strong disinfecting action and for that reason it is good to sun the tinware on a rack out of doors in a place free from dust and protected from flies. In the dairy, the utensils should be kept in a well-aired place free from strong odors and they should be inverted so that no dirt can fall into them.

Prucha of the University of Illinois Station has for some time been studying the microbial contamination of milk by utensils. He has given out a few of his results; a brief statement of them is found in Tables 47, 48 and 49.

TABLE 47.—THE BARN AS A SOURCE OF BACTERIAL CONTAMINATION OF MILK (PRUCHA)

| Barn | Number of samples | Bacteria per cubic centimeter |
|---|---|---|
| No. 1, very clean | 525 | 2,227 |
| No. 2, less clean than No. 1 | 390 | 1,073 |
| No. 3, decidedly dirty | 150 | 6,604 |

TABLE 48.—UTENSILS AS A SOURCE OF BACTERIAL CONTAMINATION OF MILK (PRUCHA)

| | Bacteria per cubic centimeter |
|---|---|
| All utensils sterile | |
| Milk leaving barn | 2,558 |
| Same milk bottled | 3,875 |
| Only bottles sterile | |
| Increase due to three pails | 57,077 |
| Increase up to clarifier | 15,353 |
| Increase due to clarifier | 172,763 |
| Increase due to cooler | 19,841 |
| Increase due to bottler | 247,611 |
| Total increase in bottled milk | 515,200 |

Table 47 shows the bacterial content acquired by the milk from the udders of the cows and the various barn influences to which it was exposed in being milked into a sterile pail.

As regards Table 48 the milk was brought by the milkers in their pails to the milk room in the barn where it was found to have an average

TABLE 49.—CONTAMINATION OF PASTEURIZED MILK BY THE BOTTLING MACHINE (PRUCHA)

| | Bacteria per cubic centimeter |
|---|---|
| Bottles and bottler sterile | |
| Raw milk | 36,860 |
| Pasteurized milk | 1,030 |
| 1st bottle of milk | 923 |
| 54th bottle of milk | 1,030 |
| Bottles sterile, bottler only washed | |
| 1st bottle | 107,500 |
| 27th bottle | 11,950 |
| 54th bottle | 4,170 |

bacterial content of 2,558 per cubic centimeter. In the milk room, the milk was poured through a strainer out of which it ran through about 20 ft. of sanitary pipe to a clarifier tank, thence through the clarifier, thence over an open tubular cooler into cans from which it was poured into a four-valve bottler. When all of these utensils were sterile the bottled milk had a bacterial count of but 3,875 per cubic centimeter which meant that there was an increase in bacteria attributable to the utensils of but about 1,300 bacteria per cubic centimeter. In contrast to this when the utensils through which the milk passed were carefully washed but were not sterilized, the milk had a bacterial count of about half a million.

Table 49 showing the test of the bottler in a sterile and in an insterile condition with pasteurized milk. In a sterile condition the first and fifty-fourth bottles had the same bacterial count but when the bottler was merely carefully washed previous to beginning bottling, the milk in the first bottles filled showed a higher bacterial count than the raw milk and it was calculated that when the bottler was not sterilized it added 4 billion bacteria to the 300 qt. of milk bottled.

The results of this extensive investigation are convincing evidence of the highly important part that milk utensils play in contaminating market milk. Milk in the course of its progress from the farm to the consumer is thoughtlessly poured from container to container and yet a little reflection would lead one to conclude that milk must pick up dirt and germs from unclean and insterile vessels of all sorts with which it comes into contact. Such being the case, the pollution derived from utensils becomes impressive.

Wherever piping is used to conduct milk about a dairy, it should be of the type catalogued as "sanitary." It is seamless and the fittings make a smooth joint. Even this kind is difficult to clean. It should be taken apart at least twice a day and when not in constant use oftener, for the lengths to be scrubbed out with long brushes and sterilized.

Acid-forming bacteria are the principal ones that get into milk from

the utensils and high counts of acid-forming colonies are likely to lead to inquiries as to the care given the dairy utensils. Hunziker states that very common sources of bacteria of the butyric acid group, that are so likely to spoil condensed milk, are cheese-cloth strainers and utensils.

Utensils are sometimes seeded with bacteria that are derived from impure waters in which they are washed and occasionally considerable loss arises from these germs causing ropy milk or imparting bad flavors to milk and butter. Some epidemics have been attributed to the washing of utensils in infected water. The water supply of the dairy is important.

**The Water Supply of the Dairy Farm.**—A dairy farm requires an abundant supply of pure water. There are two reasons for protecting it from contamination, namely: (1) fecal pollutions may infect the water with bacteria and animal parasites that cause diseases of stock or more likely of man; and (2) impure water may carry germs of various sorts that cause ropy or ill-flavored milk or that impart bad flavors to butter and other manufactured dairy products. Most writers distinguish between polluted or contaminated water and infected water, the first and second terms being applied to waters that have picked up impurities of various sorts that are not necessarily harmful to health, but the third term is restricted to waters that contain the specific germs of disease. Water that is open to contamination is so to infection. How is it then that many families regularly use polluted water without apparent ill effects except, that diarrheas may be occasionally attributed to the water? The answer is that the contaminating filth whether it is of excremental or of less objectionable origin does not contain the germs of disease. But families often do suffer from minor ills for which the impure water is responsible and they live in constant danger, for at any time infection may be introduced through the same channels that the relatively innocuous filth traverses. Thus a privy that has long leached into a well without sickening the users of the water may bring them down with typhoid fever as the result of its having been used by a typhoid bacillus carrier or by one afflicted with the fever.

Hitherto farmers have paid little heed to the protection of the purity of their water supplies. For this there are two principal reasons, the first being that many of the wells were built before our present knowledge of the causation of disease was current, and the second that the effect on health of using polluted drinking water is not always apparent. The aged grandfather lives on despite his daily dose of diluted dejecta; the infant that died of "bowel complaint" is not present to protest the old man's scoffing at the germ theory. Convenience has naturally played a determining part in locating the farm well. The result is that regardless of conditions that obviously threaten, it holds its place midway between the kitchen and the barn.

The percentage of farm wells that are polluted probably varies considerably in different dairy districts. Kellerman and Beckwith in 1906 examined the wells of dairies supplying Washington, D.C., and found 16 good, 15 fair, 17 suspicious and 12, or 20 per cent., unfit for use. The reports of the health officer of the District for the 4 years from 1905–06 to 1908–09 show that the wells on 881 dairy farms were tested and that 519 were good, 69 suspicious and 293, or 33.3 per cent., were condemned. The location of these wells is not given but they are presumably for the most part in Virginia, Maryland and the District of Columbia. Kellerman and Whittaker in their investigation of the farm water supplies of Minnesota tested 79 carefully selected and typical rural water supplies and found that 59 were polluted, usually because of careless or ignorant management. They estimate the proportion of polluted supplies in rural districts at 35 per cent. Prescott examined the water supplies of 202 dairy farms situated within 25 to 40 miles of Boston and found 14.4 per cent. so badly polluted as to be unfit for use as drinking water or for other domestic purposes.

Wells are valuable property and when one is found to be polluted it should be saved if possible, rather than condemned. Sometimes the relocation of a sink drain, a privy or a hog pen or the addition of a new curbing or cover is an effective cure of the pollution.

Prescott suggests the following form for use in inspecting farm water supplies.

Water-supply inspection

| | |
|---|---|
| Name of tenant.................... | Water piped to barn................ |
| No. of people in family............ | Character of tank, if any.......... |
| Children, servants or laborers...... | Kind of pipe....................... |
| General health of family........... | General character of soil.......... |
| Source of water, well, spring, etc.. | If well, when last cleaned......... |
| Depth of well...................... | General appearance of farm surroundings.......................... |
| Distances of sources from house drain (*a*)........................ | Is water used for cooling milk or food.... |
| Distance from cesspool or privy (*b*)..... | Sample taken at.................... |
| Distance from barnyard (*c*)........ | *Analytical data* |
| Surface wash....................... | 20°C. count........................ |
| Immediate surroundings............. | 37°C. count........................ |
| Protection against contamination from cattle, manured fields, etc.......... | Litmus lactose agar count.......... |
| | Acid formers....................... |
| Covering, if any................... | Presumptive test, dextrose broth.... |
| Date............................... | Presumptive test, lactose bile...... |
| Town and State..................... | B. coli............................ |
| Water piped to house............... | Remarks............................ |

The quantity of water needed on the farm as estimated (Trullinger) is given in Table 50.

TABLE 50.—APPROXIMATE QUANTITY OF WATER REQUIRED PER DAY ON THE FARM

| | Gallons |
|---|---|
| Each member of family for all purposes | 25–40 |
| Each cow | 12.0 |
| Each horse | 10.0 |
| Each hog | 2.5 |
| Each sheep | 2.0 |

This makes no allowance for water for steam making or for washing dairy utensils

Most ground waters are hard because the water, being long in contact with the rocks through which it makes its way and, in the case of the deeper waters, being under pressure, dissolves mineral substances from the earth. Some ground waters are only slightly mineralized while others are so heavily charged with mineral substances as to be entirely unfit for use. Hard waters increase soap consumption and also the cost of operating steam boilers for they deposit hard or soft scales that increase the fuel consumption and injure the boilers. Some waters cause foaming, while others corrode boilers and sometimes cause them to explode. In many steam plants, boiler compounds and corrective measures of various sorts are applied to make the water usable. In many industries the mineral content of water has a deleterious effect on the product manufactured. At the South Dakota Station the effect of alkali water in making butter and cheese and also on the cow and her milk was studied, but no unfavorable results were observed to attend its use.

**Contamination of Milk by Ice.**—Ice is used liberally in many dairies; in fact in summer it is all but necessary. Care should be taken to have it pure. The late Thomas M. Drown showed that ice in freezing has a decided tendency to exclude impurities, but he found this action to be most marked in the layers that are formed by the slow growth of the ice downward, because the surface in its rapid congealing entangles suspended matter, particularly if the water is stirred up by the wind. Moreover, if the ice is frozen after surface flooding, which is frequently brought about intentionally by the harvesters, it will contain all of the impurities of the water so added. In making artificial ice in the ordinary way, the entire body of water is frozen and all the impurities are concentrated in the last part of the cake to freeze. Hence an impure water is especially undesirable for ice manufacture. Likewise, when shallow ponds freeze solid, the impurities are concentrated in the bottom ice. Sedgwick and Winslow proved that typhoid bacilli perish rapidly in ice, even 98 per cent. of them dying in 2 weeks. This indicates that there is little reason for fearing that this disease may be introduced into the dairy by ice and the fact that there is no perfectly clear case of typhoid fever having infected a milk supply through the medium of ice is confirmative of this view. Artificial ice, being often used without storage,

may perhaps be somewhat less safe than natural ice. Despite the fact that there is little danger to be apprehended from the ice supply care should be taken that it is pure for while infection from impure ice is not likely, it is possible.

**Human Contamination of Milk.**—Man himself is an important source of contamination and sometimes of infection of the milk. The discharges of the mouth, nose, ears, anus and urinary bladder are most important. The operations of the toilet are such that the hands are almost inevitably soiled in its use, consequently employees should be instructed to wash their hands thoroughly before leaving the closet. It is the habit of man to be constantly fingering his mouth and picking his nose and ears consequently the hands most of the time are unclean. So, it is important that milkers and others should wash their hands carefully before beginning work. They should be taught there is an invisible dirt on the hands which is likely to seriously injure the product and that for this reason it is for the interest of the dairy that the hands should be kept away from the milk as much as possible. The practice of milking with wet hands is to be condemned as one that is sure to contaminate the milk. Milk is sometimes polluted and possibly infected by the coughing of one handling it. Fine drops of saliva are ejected into the air and fall with their contaminated germs into the milk. The clothes of people working about milk should be clean because if they are dirty they are foul-smelling and so may impart odor to the milk and also dirt and germs get into the milk from the clothes. Certified dairies make a point of the milking and the subsequent handling of milk being done by employees dressed in clean and sometimes in sterile clothes. It is too much to expect the ordinary dairyman to attempt anything of the sort but he can conveniently, and without increasing the expense of laundering, have clean overalls and jumper for milking in, that he can use for ordinary farm work when they become soiled.

**Contamination of Milk by Domestic Animals and Vermin.**—There is some danger of milk being contaminated by domestic animals and vermin. There are dairies where cats are kept to catch mice and rats and at milking time puss gets at the milk if she can. In the inferior class of dairies, the doors of the milk house are often left open consequently hens get in, and their droppings as well as those of mice and rats fall into any utensils that are carelessly left standing mouth upward. Once in a great while it is reported that a rat has been found drowned in a can of milk that has been left uncovered in the creamery over night.

**Contamination of Milk by Flies.**—While this sort of contamination is disgusting it is not of common enough occurrence to make it very important but the contamination of milk by flies in summer is constant and serious. Many of the best dairies are trying to cope with it. Flies are fond of milk and swarm wherever it is exposed, consequently in the

barn at milking time they are at the pails, cans and strainers, and in the milk house they hover about the vats, coolers, separators, bottlers, etc., falling into the milk and polluting it with germs washed from their bodies. Moreover, they light on the clean glass and tinware, soiling it with their defecations and the regurgitations from their crops. To control or even to minimize the pest is most difficult. There is usually enough manure and straw about the stables for flies to breed in myriads. Probably it helps to reduce the number of flies to keep the barns swept, the yards clean and to have the manure removed daily or at least at weekly intervals. The use of large fly traps such as the Hodges and the Minnesota results in the capture of many of the insects and tends to reduce them in number. Some dairymen try to keep out the flies by darkening the stable and leaving a small open window for the flies to get out, the milking being done by artificial light. In the flyless dairy of the United States Naval Academy at Annapolis, Md., the stables are light but they are very carefully screened. Flies are brought into the barn on the cows; so some easy way of brushing the insects off must be adopted. One in common use is to have the cows come in, through a covered passage way from which gunny sacks are hung so that they brush the cows' backs. In the milk house and in city milk plants careful screening combined with the use of fly traps and sticky fly paper is the best way to keep down the flies. The use of poison fly paper and of fly poisons of various sorts in the dairy is not advisable because they may cause accidents and because the poisoned flies drop everywhere.

**Essentials of Clean Milk Production.**—It must be apparent that with so many sources of milk pollution deserving attention, it is a difficult matter to reduce dairy sanitation to such simple terms that the precautions deemed essential will seem reasonable to, and be adopted by, the ordinary dairyman. Probably most authorities would agree that wiping the cows' udders, milking with dry hands, the use of the small-top pail, the thorough cleansing and sterilizing of utensils and the cooling of the milk to below 50°F. are all necessary to the production of clean wholesome milk.

**The North System.**—C. E. North has evolved a system which attemps to bring the number of things to be done by the dairyman, in producing clean milk, to a minimum and to interest him in the production of such milk by paying extra for it.

The North system is in operation at Homer, N. Y., at Sparks, Md., and in other places. Briefly it is this. In the dairy district is established a central station which in reality is a milk plant for the community. It is well-lighted and ventilated, has waterproof floors, good drainage and water supply. It is equipped with apparatus for washing and sterilizing utensils, for cooling, bottling and refrigerating the milk, and with a laboratory. There all the farmers' milking pails and all cans are

washed and cleaned, sterilized and dried, and the bottling of the milk, the bottle washing and sterilizing and the refrigeration and shipping of the milk are attended to. The farmers transact their business with the manager of the central plant, bring their milk there and receive their cleaned and sterilized milk pails and cans each day for use on the farm. At the dairy farms, milking must be done in covered pails provided by the station, which in transportation to the farm must be kept clean. Milk pails and cans must not be washed or sterilized at the farm. No strainers and no utensils other than those provided by the station must be used and all milk must be cooled by placing it in 40-qt. cans in ice water. The superintendent does the chemical and bacteriological work and posts the results of his tests of the farmer's milk. He also inspects the dairy farms and in doing so helps the farmers by instructing them on simple points of sanitation.

Payment for the milk is made on the basis of cleanliness as indicated by the bacterial counts and on its richness as shown by the butterfat test. Milk of a low bacterial and high butterfat test brings a better price than milk of high counts and low test. A still higher price is payed for milk of the former class from tuberculin-tested cows.

North claims to have been very successful at Homer and at Sparks, in interesting the farmers and in getting good milk. It is his belief that the dairyman, or his methods, is a factor of 90 per cent. in the production of clean milk and the equipment of 10 per cent. and he holds that dairymen trained in sanitary methods can be transferred from their own dairy district to any other and on the day of their arrival produce clean milk. This theory was actually tested by taking 10 dairymen from Oxford, Pa., where they were in the habit of producing clean milk to Kelton, Pa., where the farmers were not producing such milk but wished to produce milk of "grade A" rating. These Oxford dairymen had been producing milk having a bacterial count of about 18,000 per cubic centimeter, and the Kelton dairymen milk running about 1,500,000 per cubic centimeter. In the Kelton dairies the 10 Oxford dairymen on the day of the test produced milk that showed an average test of 9,300 per cubic centimeter. The barns, cows, and surroundings were exactly the same but the Oxford men used sterilized cans and sterilized small-top pails which the Kelton men did not. These cans and pails undoubtedly were factors in reducing the count. Other factors were that the Oxford men milked with dry hands, kept the 40-qt. receiving cans out of the dust, avoided raising a dust at milking, did not use cloth or wire gauze strainers and cooled their milk, without stirring it, by setting it in 40-qt. cans in tanks or barrels of cool water.

From this experience and other observations North concludes that the factors of primary importance in producing clean milk are:

1. Milking with clean, dry hands into covered pails.
2. Thorough washing and sterilization of milk pails, and milk cans.
3. Cooling the milk by placing it in cans in tanks of cold water, or of ice water.
4. Regular laboratory testing of milk for bacteria and the making of payments on the basis of laboratory tests.

**Dairy-farm Score Cards.**—That the conditions under which milk was produced bore an important relation to its character soon became the conviction of the pioneers in improving the quality of milk delivered in our cities; consequently the dairy inspectors of the large milk companies and of boards of health shortly began to pay particular attention to the sanitary conditions of dairy farms and to make reports to their employers thereon. For convenience in filing, and to systematize the inspection Borden's Milk Co., the Board of Health of the Town of Montclair and others substituted printed forms for written reports. These early forms were rather cumbersome and did not convey to the reader at a glance a clear impression of whether the farm was commendable or not. Confusion arose from the many details reported and the fact that their relative importance was not clearly indicated. The forms did not show the producer and consumer either the faults that should be corrected forthwith, or give them a basis for rating the sanitary condition of the farm.

Something better than the forms was needed and this was provided by W. C. Woodward, health officer of the District of Columbia, who on Jan. 9, 1904, brought out the first dairy score card. The principle on which such cards are constructed is that the different items that appear are assigned weights according to what the originator of the card deems to be their relative importance. Thus out of a total of 100 points allowed for say, 32 items on a score card, 5 points may be allowed for annual tuberculin testing, 5 for the use of the small-top milking pail, 1 for clean milking suits, 2 for construction of the milk room, etc. So, when the deductions for all the various differences have been made the sum of the points allowed is less than 100 and gives a general idea of the sanitary condition of the farm is obtained from the total score, and from a detailed consideration of the cuts, it may be seen just where the sanitation is poor and what is necessary to do to improve it. A feature of Dr. Woodward's card was the provision for scoring equipment and methods on one side and the cattle on the reverse side.

In February, 1905, R. A. Pearson of the Cornell University Station, working independently and without knowledge of the existence of the District of Columbia card, brought out a card different but in many ways similar to it. Pearson's ideas were evolved from practical experience gained at the Walker-Gordon farm at Plainfield, N. J. In July, 1906, C. B. Lane, then of the Dairy Division of the U. S. Department of Agri-

culture, prepared a modified form of card in the hope of extending the use of the score-card system and securing more thorough inspection.

The official Dairy Instructors' Association, upon its organization in 1906, appointed a score-card committee consisting of C. B. Lane, R. A. Pearson and J. M. Trueman to prepare a card that would best meet the needs of and be generally adopted by dairy inspectors. At the second meeting of the Association in October, 1907, the committee submitted a card which it was voted to print and distribute for trial and criticism among the heads of the dairy departments of the agricultural colleges. At the third meeting of the Association in July, 1908, the committee submitted a card that was constructed in the light of the criticism received and which was adopted after some minor changes had been made in it. The Committee was continued, and since, from time to time, has advised changes in the card that have been adopted by the Association. The present members are C. B. Lane, W. A. Stocking, Jr., I. C. Weld, E. Kelly, and H. A. Harding.

To promote uniformity in the use of the score-card the Dairy Division of the U. S. Department of Agriculture has coöperated with the Association in perfecting the card, a member of its staff being appointed to the Committee, and has adopted the score card in its official inspection work. Thus the card is prepared by the Official Dairy Instructors' Association and has the indorsement of the United States Government, which backing has led to its adoption in 1914 by over 200 cities, 25 State departments and 50 educational institutions. It has been sent to every city in the United States having a population of over 50,000. However, it has not been universally adopted, some cities for one reason or another, preferring to use cards of their own devising. While this card has been used in a great variety of conditions it is recognized that it is all but impossible to make up a card that will be equally well adapted for use in the different States of the Union. In New England cows are stabled half the year, in Colorado, a quarter and in Florida and southern California not at all; consequently that part of the card which pertains to barn construction and the housing of cattle is of very unequal importance in these States. So, it is to some extent with other items.

The card which is prepared by the Dairy Instructors Association and which is used by the Federal government has come to be known as the "official" score card. It is reproduced below.

"OFFICIAL SCORE CARD"
(Front)

| EQUIPMENT. | SCORE. Perfect. | SCORE. Allowed. |
|---|---|---|
| COWS. | | |
| Health | 6 | ........ |
| Apparently in good health ... 1 | | |
| If tested with tuberculin within a year and no tuberculosis is found, or if tested within six months and all reacting animals removed ... 5 | | |
| (If tested within a year and reacting animals are found and removed, 3.) | | |
| Food (clean and wholesome) | 1 | ........ |
| Water (clean and fresh) | 1 | ........ |
| STABLES. | | |
| Location of stable | 2 | ........ |
| Well drained ... 1 | | |
| Free from contaminating surroundings ... 1 | | |
| Construction of stable | 4 | ........ |
| Tight, sound floor and proper gutter ... 2 | | |
| Smooth, tight walls and ceiling ... 1 | | |
| Proper stall, tie, and manger ... 1 | | |
| Provision for light: Four sq. ft. of glass per cow | 4 | ........ |
| (Three sq. ft., 3; 2 sq. ft., 2; 1 sq. ft., 1. Deduct for uneven distribution. | | |
| Bedding | 1 | ........ |
| Ventilation | 7 | ........ |
| Provision for fresh air, controllable flue system ... 3 | | |
| (Windows hinged at bottom, 1.5; sliding windows, 1; other openings, 0.5.) | | |
| Cubic feet of space per cow, 500 ft ... 3 | | |
| (Less than 500 ft., 2; less than 400 ft., 1; less than 300 ft., 0.) | | |
| Provision for controlling temperature ... 1 | | |
| UTENSILS. | | |
| Construction and condition of utensils | 1 | ........ |
| Water for cleaning | 1 | ........ |
| (Clean, convenient, and abundant.) | | |
| Small-top milking pail | 5 | ........ |
| Milk cooler | 1 | ........ |
| Clean milking suits | 1 | ........ |
| MILK ROOM OR MILK HOUSE. | | |
| Location: Free from contaminating surroundings | 1 | ........ |
| Construction of milk room | 2 | ........ |
| Floor, walls, and ceilings ... 1 | | |
| Light, ventilation, screens ... 1 | | |
| Separate rooms for washing utensils and handling milk | 1 | ........ |
| Facilities for steam | 1 | ........ |
| (Hot water, 0.5.) | | |
| Total | 40 | ........ |

| METHODS. | SCORE. Perfect. | SCORE. Allowed. |
|---|---|---|
| COWS. | | |
| Clean | 8 | ........ |
| (Free from visible dirt, 6.) | | |
| STABLES. | | |
| Cleanliness of stables | 6 | ........ |
| Floor ... 2 | | |
| Walls ... 1 | | |
| Ceilings and ledges ... 1 | | |
| Mangers and partitions ... 1 | | |
| Windows ... 1 | | |
| Stable air at milking time | 5 | ........ |
| Freedom from dust ... 3 | | |
| Freedom from odors ... 2 | | |
| Cleanliness of bedding | 1 | ........ |
| Barnyard | 2 | ........ |
| Clean ... 1 | | |
| Well drained ... 1 | | |
| Removal of manure daily to 50 feet from stable | 2 | ........ |
| MILK ROOM OR MILK HOUSE. | | |
| Cleanliness of milk room | 3 | ........ |
| UTENSILS AND MILKING. | | |
| Care and cleanliness of utensils | 8 | ........ |
| Thoroughly washed ... 2 | | |
| Sterilized in steam for 15 minutes ... 3 | | |
| (Placed over steam jet, or scalded with boiling water, 2.) | | |
| Protected from contamination ... 3 | | |
| Cleanliness of milking | 9 | ........ |
| Clean, dry hands ... 3 | | |
| Udders washed and wiped ... 6 | | |
| (Udders cleaned with moist cloth, 4; cleaned with dry cloth or brush at least 15 minutes before milking, 1.) | | |
| HANDLING THE MILK. | | |
| Cleanliness of attendants in milk room | 2 | ........ |
| Milk removed immediately from stable without pouring from pail | 2 | ........ |
| Cooled immediately after milking each cow | 2 | ........ |
| Cooled below 50° F | 5 | ........ |
| (51° to 55°, 4; 56° to 60°, 2.) | | |
| Stored below 50°F | 3 | ........ |
| (51° to 55°, 2; 56° to 60°, 1.) | | |
| Transportation below 50°F | 2 | ........ |
| (51° to 55°, 1.5; 56° to 60°, 1.) | | |
| (If delivered twice a day, allow perfect score for storage and transportation.) | | |
| Total | 60 | ........ |

Equipment .............. + Methods .............. = .............. **Final Score.**

NOTE 1.—If any exceptionally filthy condition is found, particularly dirty utensils, the total score may be further limited.

NOTE 2.—If the water is exposed to dangerous contamination, or there is evidence of the presence of a dangerous disease in animals or attendants, the score shall be 0.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
DAIRY DIVISION.

**SANITARY INSPECTION OF DAIRY FARMS.**

**SCORE CARD.**
Indorsed by the Official Dairy Instructors' Association.

Owner or lessee of farm ..............................

P. O. address .............................. State ..............................

Total number of cows .............................. Number milking ..............................

Gallons of milk produced daily ..............................

Product is sold by producer in families, hotels, restaurants, stores,

to .............................. dealer.

For milk supply of ..............................

Permit No. .............................. Date of inspection .............................., 191

REMARKS: ..............................

..............................

..............................

..............................

(*Signed*) ..............................
*Inspector.*

In practice the score card has served several purposes. In the first place, it has been an aid to inspectors in their work, for on filling out all its items they could be sure that no important points of inspection had been overlooked while by comparing the scores the relative merits of dairy farms could be judged; also, by reflecting on the mental impressions made by the farms and on the scores a check on both could be had so that the opinions that the inspectors had of the several dairies in their districts was less likely to be biased, either by the personal impression made by the dairyman or by the scores themselves. Besides, the cards served as guides in instructing dairymen on the importance of cleanliness in handling milk; so for this, and other reasons it is advisable to leave a carbon copy of the score at the farm. Moreover, employers of several inspectors could check the work of their staffs by transferring their men from one district to another and comparing the scores turned in. Finally, the score cards are conveniently filed for reference.

It should be understood that the figures obtained by scoring are not an exact mathematical expression of the sanitary rating of the farm.

On the contrary they are greatly influenced by the system of cuts employed and somewhat also by the mental attitude of the inspector. Thus one system may be lenient, in that it makes some allowance for even an attempt to approach the conditions postulated for a perfect score, whereas another may be severe, in that it makes no allowances of the sort. For example, if 6 points are allowed for the item of cleanliness of the stable, the inspector under one system may be instructed to give 3 points if it is half clean and 2 if it is a third clean, while the inspector under the other system may have orders to cut 6 points if the stable is not immaculately clean. Likewise, it is practically impossible for the inspector at different times to score the same farm exactly alike. When he is in an amiable mood conditions at the farm are likely to appear better, and his cuts are possibly a trifle less than when he is scoring under the spur of a rebuke from his superior, or when he is dealing with a refractory dairyman. So it is not to be expected that the scores of the inspectors operating under different chiefs will be strictly comparable or that those of individual inspectors will more than very closely approximate the truth. These limitations of the score card are frankly recognized and in practice are to some extent guarded against; they have not militated against its extensive adoption by dairy companies, cities, and States nor roused opposition among farmers to its use. In fact the score card has made friends rapidly and instead of inciting strife has stirred farmers to emulate one another in securing high scores.

The score card is a means of stating the physical conditions of the dairy. It was designed to record sanitary conditions on the farm and to secure their betterment in order that overcrowding of cows in the stables, poor ventilation of buildings used for dairy purposes, filthy barns, undrained barnyards, location of hog pens and manure heaps close to where the milk was handled, the use of poorly constructed, battered or worn out utensils and a host of other objectionable conditions that frequently were found on dairy farms and that from time to time occasioned publicity campaigns and brought dairying into disrepute, might give place to other conditions which would secure the approval of the public and establish confidence in the business. While it was believed that some of these things in some degree affected the quality of the milk it was recognized that others did not. The score card attempted to make sure that the environment and especially the *methods* of milk production were clean and comparable with those that attend the production of other foods, rather than to estimate closely the quality of milk produced on any particular farm. It has been very successful in bringing about reforms along the former lines; to the latter purpose it was never intended to be applied. No doubt in the main the dairies that receive high scores produce better milk than those with low ones. Thus the committee on farm sanitation of the International Association

of Dairy and Milk Inspectors instances the results obtained in an Eastern city of about 100,000 population where a comparison of 1,392 bacterial counts from 484 dairies during the 5 years 1910, 1911, 1912, 1913 and 1914 showed that:

47 dairies scoring over 80 gave an average count of 25,000 bacteria per c.c.
46 dairies scoring 70 to 80 gave an average count of 98,000 bacteria per c.c.
334 dairies scoring 61 to 70 gave an average count of 352,000 bacteria per c.c.
711 dairies scoring 50 to 61 gave an average count of 470,000 bacteria per c.c.
254 dairies scoring under 50 gave an average count of 566,000 bacteria per c.c.

But results do not always have this trend. High-scoring dairies often yield milk of high bacterial count, and that low-scoring dairies must necessarily yield high counts is untrue.

Brainerd and Mallory, in 1911 studied the relation between the scorings of 54 dairies on the card in use in Richmond, Va., and the bacterial counts obtained on milk sampled at milking time at these same dairies and plated from 1 to 3 hr. thereafter. The results appear in Table 51.

Table 51.—Relation between Dairy Farm Scores and Bacterial Counts (Brainerd and Mallory)

| Score | Number of dairies | Number of counts | Average number of bacteria per cubic centimeter |
|---|---|---|---|
| 67–70 | 1 | 4 | 8,062 |
| 70–73 | 2 | 7 | 61,838 |
| 73–76 | 2 | 19 | 35,195 |
| 76–79 | 12 | 35 | 31,378 |
| 79–82 | 11 | 40 | 36,468 |
| 82–85 | 11 | 39 | 33,745 |
| 85–88 | 5 | 18 | 38,814 |
| 88–91 | 4 | 12 | 21,095 |
| 91–94 | 2 | 7 | 18,799 |
| 94–97 | 1 | 4 | 19,769 |
| Total | 54 | 185 | |

From these experiments the authors concluded that it is possible to produce good milk under conditions which would give a score below any effective standard which might be established and that it is not logical to condemn milk by a standard that bears no fixed relation to its purity or sanitary properties. They held the chief defect of the score card to be that, as a measure of the sanitary properties of milk, none of the points scored have a permanent value under all conditions and it is questionable whether they have a definite value under any given set of conditions. However, they recognized the score card to be of the greatest influence in improving the quality of milk and advocated its use until some better method should be developed. They suggested

giving the bacterial count a fixed value in the score card, perhaps to half the score.

Brew of the New York Station has recently compared the bacterial content of milk produced in 34 dairies scored by three different cards, namely, the "official," the Cornell, and the New York City, and found no correlation whatever between scores and the counts. He states that the reason for the discrepancy cannot be certainly given but that the most apparent reason is that a large number of items included on the score card have little relation to the number of bacteria in the milk. He says that in the district studied, it was not true that low-scoring dairies were necessarily insanitary and filthy because low-scoring dairies were found that compared favorably in point of cleanliness with high-scoring ones.

In spite of the fact that the score card is not intended to distinguish the quality of milk, there has gradually grown up a tendency to apply it to this very purpose, and of late there has developed a well-defined movement to convert it from its original use and make it a standard of marketing.

The growth of the desire for such a change has been slow. Its origin may be traced to the policy of boards of health requiring that dairies should attain a certain minimum score in order for the milk therefrom to be admitted for sale within their jurisdiction and in their publishing the scores. Under such conditions the consumers became interested in the scores and very generally made the assumption that the dairies with the highest scores had the best milk. The fact that certain of the large milk companies of Chicago paid a premium for milk from dairies scoring 65 or more tended to foster the same idea and the action of the Public Health Council of the State of New York allowing health officials to grade milk either on the bacterial counts or on dairy scores alone, will well-nigh convince the milk-consuming public that dairy scores are an indication of milk quality.

**Future of the Score Card.**—With the understanding that the effect of the cow stable and its surroundings is of less importance than other factors on the quality of milk there has developed a tendency to lay less emphasis on dairy inspection and more to judge the fitness of milk for public consumption on quality alone. In fact, the question is raised whether a satisfactory milk supply is best and most economically secured by inspection or laboratory control. Hitherto, the majority of cities have relied on the former method, but since the grading of milk has been undertaken there has been a decided swing toward bacteriological and chemical examinations. The score card has improved the environment in which the dairyman works, has educated him along sanitary lines, and has stimulated him to take pride in his products so that it seems intrinsically sound and desirable to retain, but those who have given the matter

most study are convinced that the card will have to be remade so that the points that go to make up the score will be given for those things that are known to affect milk quality. It was to so modify the score card that the studies of Harding and his collaborators on barn conditions were undertaken and others have been working with this object in view.

North in a forthcoming article in the *American Journal of Public Health* proposes a card that is based on the study of various score cards, and on data that he has accumulated. He believes that the great factors in producing good milk are proper milking, cooling, and sterilizing. The things that have an important effect on the score he tabulates thus:

| | Per Cent. |
|---|---|
| 1. Temperature: | |
| (*a*) Winter or summer weather may reduce bacteria | 90 |
| (*b*) Ice or spring water for cooling may reduce bacteria | 90 |
| (*c*) Morning's milk or night's milk may reduce bacteria | 60 |
| 2. Covered milk pails may reduce bacteria | 90 |
| 3. Sanitation (minus cooling) may reduce bacteria | 87 |
| 4. Sterilization of utensils may reduce bacteria | 99 |
| 5. Type of producer at shipping stations may reduce bacteria | 84 |
| 6. The human factor may reduce bacteria | 99.99 |
| 7. The cow stable and surroundings may reduce bacteria | less than 1 |

North separates the item of the best score cards into those of primary and those of secondary importance in strict accordance with the degree in which they affect the number of bacteria in the milk which makes the number of items of primary importance very few and those of secondary many. He retains the vertical division of the card into equipment and methods, but he divides it also by a horizontal line in such a way that above it is a list of equipment and methods of primary importance, and below it one of equipment and methods of secondary importance. The things of primary importance affect the decency of the milk and those of secondary, the decency of the dairy. The card allows 100 points, of which 30 are for primary equipment, 60 for primary methods, 3.30 for secondary equipment, and 6.70 for secondary methods. The card may be summarized as shown on page 181.

Whether this card which North has proposed will be adopted in some form or not cannot be predicted but even in the skeleton form that it is given here it serves to bring out how differently many today regard dairy scoring from the way it was worked out in the "official" card. It is the author's opinion that the new way will prevail as soon as enough data has been collected from various sources to give a sound basis for revision. The change will be radical and it therefore demands thoughtful consideration by all concerned, the medical profession, health officers, milk companies and the dairymen themselves.

SUMMARY OF THE NORTH SCORE CARD

| Primary Equipment | Primary Methods |
|---|---|
| Milking:<br>Size, condition and character of pails, cans and lids.<br>Strainers of cotton or cheese-cloth and held in place by a good sanitary holder.<br>No metal strainers allowed. | Milking:<br>Udder clean before milking.<br>Milker's hands clean before milking.<br>Small mouth milk pails in use.<br>Milk strained in a clear atmosphere through cotton or fine cheese-cloth. |
| Cooling:<br>Ice supply.<br>Water sypply.<br>Cooling tank.<br>Smooth metal stirring rods. | Cooling:<br>Milk chilled in ice water to 50°F.<br>Milk chilled in running water to 55°F.<br>Milk chilled in standing water to 60°F. |
| Sterilizing:<br>Boiling water or steam.<br>Alkali wash powder.<br>Scrubbing brushes used. | Sterilizing:<br>Utensils rinsed in clear cold water right after using.<br>Scrubbed with brushes in alkali powder and rinsed.<br>Sterilized in boiling water or steam.<br>Strainers washed in alkali solution and boiled. |
| **Secondary Equipment[1]** | **Secondary Methods[1]** |
| Cow Stable:<br>Location and construction.<br>Air and ventilation.<br>Light. | Cow Stable:<br>Care, free from dirt, dust and odor.<br>Cow Yard:<br>Well drained.<br>Manure:<br>Distance removed. |
| Milk House:<br>Location and construction. | Milk House:<br>Cleanliness, freedom from flies and rubbish. |
| Privy:<br>Location, construction and screening. | Employees:<br>Conditions of clothing.<br>Cow feed:<br>Condition and quality.<br>Privy:<br>Condition and disposal of contents. |

[1] The primary equipment and methods are scored in whole numbers, the secondary in decimals. Under secondary equipment and methods only outline headings are given; the card is very detailed.

**Dirty Dairies.**—In this chapter there has been no attempt to portray the evils of dirty dairying. Within the memory of men now living the milk business has been raised from a primitive trade to the dignity of a recognized industry. When the evolution commenced, modern sanitation itself was a new thing and its application to dairying an experiment. It was soon found that the dairy business had every need of the new science. Almost inconceivably dirty cows and filthy barns, miry barnyards, menacing privies, impure wells and cisterns, and unclean

utensils were part and parcel of the milk trade of every city. Clean-up campaigns were the order of the day and the disgusting conditions that were often disclosed were all but unbelievable. The medical profession, working largely through boards of health, was chiefly responsible for the operation that cut the dirt out of the milk business, for speaking by and large, the day of dirty dairying is over. It still persists in some cities where milk companies and milk inspectors are mixed up in politics, it undoubtedly persists in communities too small or too niggardly to pay for inspection, and it flourishes in granger towns where business men feel that the farmer's trade is so important that they had rather drink dirty milk than disturb business by a clean-milk campaign, but in general both milk producers and milk consumers are done with it, and its nauseating details have been so often blazoned forth that it seems unnecessary to say more about it. However, because of the importance that they once had and because of the acrimonious campaigns that have been waged against them in New York, Cincinnati, Louisville, and other American cities, it seems well to say a little about "slop" or "swill" dairies.

**Slop Dairies.**—They were so-called because the cows were fed on the slop or refuse from distilleries. As early as 1848, a committee of the New York Academy of Medicine investigated and made a report on the slop dairies that supplied the city. This action was taken because of the oral and written statements made by physicians, testifying to the evil effect of such milk on children and to the improvement that took place in their condition when the use of such milk was discontinued.

The committee stated that in 1842, the daily milk supply of the city was 15,000 gal. but at the time of the investigation had greatly increased and that some of the milk was brought long distances by steam, the principal source of supply being:

1. Milk from grass-fed cows, as from Orange County, for example, that was brought by steam.
2. Milk from cows fed partially on distillery slop and that was brought to the city by steam as from Newburg, for example.
3. Milk from cows fed partially on distillery slop in the neighborhood of the city, as at Brooklyn, Wallabout, Bloomingdale, etc.
4. Milk produced in the city or on its outskirts from cows fed solely on distillery slop, as on Long Island, at 16th and 42d Streets.

The cow sheds at Johnson's distillery, 16th and 10th Avenue, are described in detail. At this particular plant the cows were cleaned but this was exceptional and the filth in most sheds was augean. The number of cows at Johnson's ranged between 2,000 and 4,000. Several thousand were kept confined in a small space and deprived of exercise. Some hundreds were under one roof but a few feet above their heads, the space being heated to suffocation by the sun, by steaming slops and by the breath and body exhalations of the cows. No litter was provided and

the air was vitiated by the constantly flowing urine. The animals were brought to the city soon after calving. At first they refused the slop but afterward became fond of it. Often they became sick and many died soon after arrival. Sore foot, in several cases due to a fungus growth and accompanied by carious bones and a discharge of pus, was one of the diseases. Caries of the teeth was common in cows that had been fed slop for 6 months and in time the teeth loosened and fell out.

Later, *Frank Leslie's Weekly* made its famous onslaught on the swill dairies. This was known as the short or stump-tail cow campaign for the cows were represented as suffering from a disease that caused part of the tail to drop off. The expose was based on a report made to the Brooklyn common council in 1857 by a committee of 11 appointed in response to a petition of John T. Hildreth et al. for the investigation of cow stables. The series of articles in *Leslie's* began on May 8, 1858, and ran over several months. They are profusely illustrated with drawings and cartoons by Nast and other artists and depict the evils of

*Courtesy of W. E. Miller.*

Fig. 31.—Method of conveying slop at a Cincinnati swill dairy. Such dairies are now entirely eliminated by the Pure Food Division of the Cincinnati Board of Health.

the swill dairies very fully and clearly. Undoubtedly the expose is one of the severest arraignments of any business ever published. It served a useful purpose in its day, is an instructive record of bygone conditions and is interesting as one of the very first instances of pitiless publicity being used to compel improvement in the production of food and in general sanitation. The incident is utilized in Ford's novel, "The Hon. Peter Sterling."

Since then, many States, including Pennsylvania, Illinois, Kentucky and Indiana have prohibited the sale within their borders of milk from slop-fed cows.

In 1906–1908, largely under the leadership of O. P. Geier, a vigorous campaign was waged against the slop dairies of Cincinnati. Of conditions there C. B. Lane says:

"I visited the swill dairies supplying milk to the City of Cincinnati and found

filth and insanitary conditions almost indescribable by words commonly found in the dictionary.

"This condition is due in a large measure to a swill diet which causes diarrhea and keeps the platform saturated with manure mingled with swill. Many of the cows were in an emaciated condition, some were coughing and looked sick and one was seen dead just outside the stable. The cows never go out for exercise, at least in winter, and are tied up in small, cramped, slippery stalls, to drink the nauseating sour swill and breathe the close, stench-laden air for months until they are sent to the shambles. These herds would furnish a profitable field for investigation by the Humane Society as the treatment accorded the animals is cruel in extreme.

"Invariably the stables were filled with steam rising from the swill, which condensed on the ceiling and continually dropped or ran down the walls. No attempt was made to ventilate the stables—in fact the windows were generally nailed down and all possible openings covered with boards.

"Milk rooms were generally connected directly with the stable and were just as filthy and dirty. There was no provision for properly cleaning the cans and a considerable quantity of dirty water was frequently found at the bottom of them."

One of the arguments used in the campaign against these dairies was that they discouraged legitimate dairying, it being impossible for dairy farmers to maintain herds fed in the normal way in the face of competition from slop-fed herds. The fight against these dairies was ultimately won, it having been found after 2 years' attempt by the health department, that regulation was a failure.

It should be understood that distillery slop can be fed under such conditions as to produce wholesome milk. The chances are very great that it will not be fed in this way. Henry says that:

"Distillery slop is a watery attenuated food substance. Being produced in great quantities it must be gotten out of the way quickly and it is usually pumped into feeding sheds and there distributed in troughs to animals which stand and drink it. The great quantities drunk cause the passage of enormous amounts of water through the kidneys. Unless the greatest precautions are taken, the liquid leaks and spills everywhere and the urine distributes itself likewise. Often the animals have little hay and other food. They are overfed on this one product because it must be quickly and continuously disposed of. Good flesh in steers or good milk from cows can hardly be produced under such conditions."

The practical results of the campaigns against slop dairies have been two, namely: (1) they have been largely wiped out with consequent improvement of the city milk supply; and (2) the distilleries have installed plants for evaporating and drying the slop so that they are now recovering and selling a valuable cattle feed.

**The Cost of Milk Production.**—The several elements of production, namely: the raising of proper crops, the oversight of labor, the erection and maintenance of barns and other buildings, the formation and im-

provement of the herd, its feeding and care, the sanitation of the farm and the protection of milk from pollution, all must be competently handled by the dairy farmer but in addition to the ability to cope with these problems, to achieve success he must have business ability. It must be evident that the lax conduct of any one of these phases of dairying is likely to raise the cost of production and that the prosperity of the dairyman, the success of the city milk dealer and the weight of the burden that falls on milk consumers, who in reality support the entire dairy business, depend in large measure on the economical and efficient management of the dairy farm. It is only of recent years that farm accounting has been so systematized that fairly accurate production costs can be calculated. In particular the cost of milk production has only been approximated. However, of late several computations have appeared that are illuminating. The problem is difficult, for conditions on the farms vary much, and neither horses nor men are constantly employed in labor that can be properly charged to milk production. Then in making a statement of costs there is justifiable difference of opinion as to whether certain costs shall be excluded or not, and if they are included as to how they shall be grouped. The costs of milk production fall under three main heads, namely: feed, labor and fixed charges. Labor is a fixed charge but it is so distinct from the other items listed thereunder that its separation seems warranted. There are presented in Table 52, estimates of the cost of milk production in nine of the States. It will be observed that the items that enter into the calculations of fixed costs are not the same in the divers estimates, but the variation is perhaps more apparent than real, for the item "sundries" is an inclusive one. In these studies no allowance has been made for skim-milk which would be necessary if the dairying was of a class wherein much remained on the farm which is not the case in dairies supplying the city milk trade. The cost of feed in every instance is 50 per cent. or more, of the total cost, the labor item varies from 20 to 30 per cent. thereof. Caution is needed in making comparisons between the different estimates for the cost of production varies not only in different States but in different parts of the same State. However, it is noticeable that in the New England States and New Jersey the feed costs are higher than elsewhere. In these States and in Maryland the cost of a quart of milk is between 4.5 and 5 cts. In the States of the Middle West the cost of a quart of milk is from 2 to 2.5 cts. The figures for the particular county in New York that was studied are comparable with those for the West but it is expressly stated in the bulletin wherein the results were published that in many other counties of the State, costs would be much higher. The Agricultural Experiment Stations of Washington, Oregon and California have none of them issued bulletins on the cost of milk production in those States. A. B. Nystrom of the Washington Station

TABLE 52.—COST OF MILK PRODUCTION

| State | New Hampshire, N. H. Col. Expt. Sta. | Massachusetts, Mass. Ag. Expt. Sta. | Connecticut, Storrs Ag. Expt. Sta. | New York, Cornell Univ. Ag. Expt. Sta. | New Jersey, N. J. Ag. Expt. Sta. | Maryland, Hoard's Dairymen | Ohio, Ohio Ag. Col. Expt. Sta. | Minnesota, Univ. of Minn. Ag. Expt. Sta. | Illionis, Univ. of Ill. Ag. Expt. Sta. |
|---|---|---|---|---|---|---|---|---|---|
| Investigator | Rasmussen | Lindsey | Trueman | Hopper and Robertson | Minkler | ........ | Erf | Cooper | Fraser |
| Date | 1911 | 1896–1911 | 1906–11 | 1913–14 | 1909 | 1913 | 1913 | 1905–09 | 1909 |
| Basis of study | Lyndeboro Cow Test Assoc. farms in Sta. | Station herd | Station herd | Data collected by the Jefferson Co. Farm Bureau | Station herd | 10 herds comprising 250 cows in Baltimore Co. | Cow Testing Assoc. and advanced registry records in Ohio | Data collected at Northfield, Rice County, a well-developed dairy community | Station herd and herds in State |
| Feed | $73.03 | $89.24 | $83.50 | $51.57 | $121.60 | $51.30 | $61.00 | $27.50 | $4.20 |
| Labor | 32.33 | 35.00 | 30.00 | 23.12 | 42.96 | 37.05 | 25.00 | 18.66 | 19.00 |
| Fixed charges | 42.37 | 38.15 | 31.40 | 23.78 | 27.24 | 38.12 | 26.50 | 13.84 | 13.54 |
| Depreciation on cow | 8.83 | 11.25 | 13.00 | 3.50 | 10.00 | ........ | 3.00 | 3.19 | 4.14 |
| Barn—int. taxes, ins. | 9.05(*a*) | 7.50 | 8.40 | ........ | 5.00 | ........ | 3.00 | 2.46 | 4.00 |
| Cow—int. taxes, ins. | 4.55 | 5.25 | ........ | ........ | 5.00 | ........ | 4.00 | 2.35 | 2.00 |
| Bedding | 4.00 | ........ | 5.00 | ........ | 5.31 | ........ | 2.00 | | |
| Bull | 3.79 | 4.00 | 3.00 | ........ | 1.93 | ........ | 2.00 | 1.98 | 2.00 |
| Ice | 2.17(*b*) | ........ | ........ | ........ | ........ | ........ | 2.50 | | |
| Hauling milk | 7.18 | ........ | ........ | 7.75 | ........ | ........ | 5.00 | | |
| Sundries | ........ | ........ | ........ | ........ | ........ | ........ | 5.00, | 3.86 | 1.40 |
| Veterinary service, supplies, tools, etc. | 2.80 | 10.15(*c*) | 2.00 | 12.53 | | | | | |
| Total cost | 147.73 | 162.39 | 144.90 | 98.47 | 191.80 | 126.70 | 112.50 | 60.00 | 74.54 |
| Credit, calf and manure | 18.00 | 17.00 | 13.00 | 18.23 | ........ | 16.50 | 26.00 | ........ | 20.00 |
| Net cost | 129.73 | 145.39 | 131.90 | 80.24 | 191.80 | 110.20 | 86.00 | 60.00 | 54.54 |
| Feed cost, per cent. of total cost | 49.4 | 54.9 | 57.6 | 52.4 | 63.4 | 40.7 | 54.2 | 45.8 | 56.2 |
| Labor cost, per cent. of total cost | 21.9 | 21.6 | 20.7 | 23.4 | 22.3 | 29.3 | 22.2 | 31.1 | 25.5 |
| Fixed charges, per cent. of total cost | 28.7 | 23.5 | 21.7 | 24.2 | 14.3 | 30.0 | 23.6 | 23.1 | 18.3 |
| Production on which cost of milk is figured | 6,463 lb. | 6,036 lb. | 6,379 lb. | 6,621 lb. | 8,661 lb. | 5,222 lb. | 6,000 lb. | 5,252 lb. | 6,000 lb. |
| Milk—cost per cwt | $2.01 | $2.04 | $2.07 | $1.21 | $2.21 | $2.11 | $1.10 | $1.14 | $0.91 |
| Milk—cost per qt | 0.0452 | 0.0459 | 0.0465 | 0.0273 | 0.0498 | 0.0475 | 0.0248 | 0.0257 | 0.0204 |

(*a*) Including $3 for repairs to barn. (*b*) Including $0.50 for fuel. (*c*) Including ice and bedding.

says that in Washington the cost of production varies quite as much as in various parts of the United States. The western part of Washington, having heavy rainfall, is well-adapted to dairying and so milk can be produced cheaply, whereas the eastern portion being semi-arid is not so well-suited to the industry, consequently the production of milk is more costly. In parts of the State a hundredweight of 4 per cent. milk can be produced for 30 cts.; in others the cost would be a dollar.

Several of the investigations have shown that the quantity of milk produced per cow bears an important relation to the cost of production. This is of greatest significance to the dairyman who is not selling milk on a butterfat basis. Table 53, from the New York study, illustrates the point and the lesson it inculcates is that a poor-producing cow is an expensive milk maker and therefore it behooves the dairy farmer to improve his herd.

Table 53.—Relation of Yield to Cost of Production (Hopper and Robertson)

| Group | Number of cows | Average production | Net cost of production | Net cost, per cent. |
|---|---|---|---|---|
| 5,000 lb. or less | 159 | 4,161 | $57.20 | $1.37 |
| 5,001–7,000 lb. | 360 | 5,993 | 74.40 | 1.24 |
| 7,001–9,000 lb. | 214 | 7,843 | 92.00 | 1.17 |
| 9,001–11,000 lb. | 84 | 9,763 | 109.00 | 1.12 |
| Over 11,000 lb. | 17 | 12,377 | 112.60 | 0.91 |
| Total | 834 | | | |
| Average | | 6,621 | 80.24 | 1.21 |

The price that the dairyman receives for his milk is usually determined by cheese factories, creameries or large city milk dealers. Sometimes the price is a matter of direct agreement between the dairyman and the buyer, often it is established after much parleying between the purchaser and dairymen's associations. The price is usually higher where there is competition for the milk either between different milk dealers or between milk dealers and creameries. Where a single interest controls the district the buyer virtually determines the price. The contract is usually made so that more is paid for the milk in some months of the year than others. This is made evident by Table 54 which gives the average prices paid for milk in different sections of the United States in 1914. According to this table milk was highest in December when the price was 4.205 cts. a quart, and lowest in June when it fell to 3.264 cts. The average price for the year was highest in New England, 4.657 cts. a quart, and lowest in the Middle Atlantic where it was only 2.841 cts. One dealer in the Middle Atlantic States reported that in June he paid but 90 cts. a hundredweight or 1.9 cts. a quart. The Middle Atlantic

Table 54.—Average Price per Quart Net, Paid Farmers at Farmers Shipping Stations in the United States in 1914(*d*)

| Section(*b*) | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | 1914(*a*) average | 1913(*c*) average | 1912 average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New England | 4.883 | 4.956 | 4.769 | 4.500 | 4.215 | 4.195 | 4.360 | 4.447 | 4.603 | 4.969 | 5.049 | 5.039 | 4.657 | 4.571 | |
| West South Central | 4.896 | 4.896 | 4.562 | 4.396 | 4.396 | 4.396 | 4.396 | 4.396 | 4.729 | 4.896 | 4.896 | 4.896 | 4.646 | 4.312 | |
| Pacific | 4.466 | 4.399 | 4.046 | 3.811 | 3.811 | 3.911 | 3.943 | 3.973 | 4.111 | 4.242 | 4.237 | 4.350 | 4.111 | 4.270 | |
| South Atlantic | 4.495 | 4.467 | 4.392 | 4.142 | 3.551 | 3.523 | 3.542 | 3.542 | 3.868 | 4.425 | 4.567 | 4.604 | 4.094 | 4.031 | |
| East South Central | 4.604 | 4.439 | 4.439 | 3.772 | 3.190 | 3.190 | 3.486 | 3.691 | 3.691 | 3.939 | 4.023 | 4.023 | 3.874 | 4.259 | |
| West North Central | 4.015 | 3.948 | 3.882 | 3.635 | 3.208 | 3.309 | 3.386 | 3.493 | 3.615 | 3.758 | 3.875 | 3.924 | 3.670 | 3.508 | |
| Middle Atlantic | 4.139 | 3.965 | 3.825 | 3.408 | 2.920 | 2.841 | 3.046 | 3.263 | 3.575 | 3.949 | 4.169 | 4.204 | 3.608 | 3.634 | |
| East North Central | 3.974 | 3.932 | 3.833 | 3.512 | 3.097 | 3.057 | 3.262 | 3.422 | 3.551 | 3.766 | 3.916 | 3.955 | 3.606 | 3.503 | |
| Mountain | 3.864 | 3.864 | 3.606 | 3.231 | 3.231 | 2.973 | 3.098 | 3.098 | 3.356 | 3.606 | 3.606 | 3.864 | 3.449 | 3.642 | |
| True average | 4.203 | 4.123 | 3.996 | 3.678 | 3.280 | 3.264 | 3.416 | 3.459 | 3.745 | 4.023 | 4.163 | 4.205 | 3.804 | 4.849 | 3.565 |

(*a*) 226 sources reporting.

(*b*) As defined by U. S. Census Bureau, viz.: New England. Me., N. H., Vt., Mass., R. I., Ct. Middle Atlantic. N. Y., N. J., Pa. East North Central. Ohio, Ind., Ill., Mich., Wis. West North Central. Minn., Iowa, Mo., N. D., S. D., Neb., Ks. South Atlantic. Del., Md., D. C., Va., W. Va., N. C., S. C., Ga., Fla. East South Central. Ky., Tenn., Ala., Miss. West South Central. Ark., La., Tex., Okl. Mountain. Mont., Idaho, Wyo., Col., N. Mex., Ariz., Utah, Nev. Pacific. Wash., Ore., Calif.

(*c*) 131 sources reporting.

(*d*) *Weekly News Letter*, U. S. Dept. Ag., vol. 2, No. 38, Apr. 28, 1915.

States show the greatest range in prices, 1.363 cts., the December price being 4.204 cts. and the June price 2.841.

The late G. M. Whitaker investigated the extra cost of producing clean milk and found that to increase the dairy score from 42 points which he believed should be attained as a natural and necessary incident of milk production, to approximately 70 points, which he held practically met modern sanitary requirements, the following added expenses would be incurred in a 15-cow dairy.

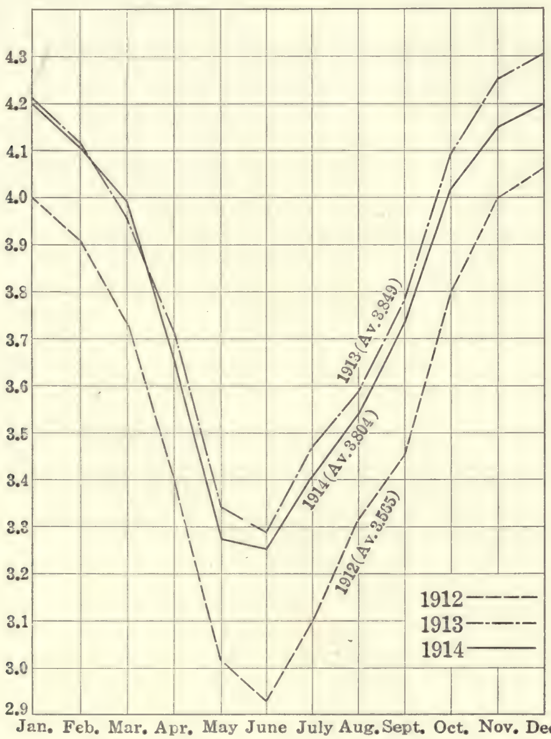


FIG. 32.—Average monthly prices, for the entire United States, of milk in cents per quart, at farmers' shipping stations, in the years 1912, 1913, and 1914.
*(Adapted from the "Weekly News Letter" of the U. S. Dept. of Agriculture.)*

"There may be an added expense of 5 cts. per cow per day for labor, plus, in extreme cases, 5½ cts. for new or additional equipment; and if we add 5 cts. more to remunerate the proprietor for his extra care and vigilance there will be an extreme increase of 15½ cts. per cow per day. The product of a cow ranges from 4,000 to 10,000 lb. of milk a year, or from 5 to 12 qt. a day. The added expense for labor would therefore amount to about ½ to 1 ct. a quart, and in rare instances where great additional expense is required for repairs, new construction, and new equipment, this might raise the increase 1 to 2 cts. a quart more. The allowance for extra remuneration to the dairyman for added care would bring the total added expense per quart from 1½ cts. when cows give large

amounts of milk to 3 cts. when the cows are of low production. The added actual labor and the remuneration of the proprietor—without any new construction or equipment—would increase the expense from 1 to 2 cts. a quart. This added expense of improved methods and equipment, however, would no doubt be partly offset by increased production and increased economy of feed, so that the net extra expense of producing clean milk would probably be somewhat less than the figures given."

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# CHAPTER V

## THE TRANSPORTATION OF MILK

**The Hauling of Milk.**—After milk has been produced on the farm it must be carried to the consumer. A considerable number of dairymen either load the milk into their own delivery wagons and retail it themselves or dispose of it to a neighbor who does so. Others take their milk in cans to a creamery or country milk plant where it is sometimes pasteurized and almost always cooled after which it is put into other cans or into bottles for shipment to the city, but most farmers carry their milk right to the depot where it is picked up by milk trains.

The hauling of milk is a source of expense to the farmer. A deal of time is wasted in those dairy districts where it is the custom for every farmer to drive to the station with the few cans of milk that he produces. In more progressive communities the farmers economize by combining their loads, the hauling being done either by several neighbors who agree to carry the milk in turn, or by a driver who is hired to haul it all. There are some objections to the latter practice but they are usually overcome where there is a disposition to do so. A careless driver may confuse the lots of milk shipped by the different farmers and a dishonest one may tamper with the milk. Milk that is handled by a truckman is often exposed to deteriorating influences of various sorts. He usually follows the main road and so farmers living on branch roads bring their milk to the thoroughfare to be picked up. Consequently it stands exposed to sun, rain and dust, to the attention of animals and of mischievous persons to its injury. The same dangers are often encountered when milk is left exposed and unguarded on railway platforms.

Unless proper precautions are taken of milk in transit it is apt to be injured in cold weather by freezing, and in warm, it is likely to be decomposed by bacterial growths.

The costs of teaming milk are illustrated in Tables 55, 56 and 57 which are adapted from *Bulletin* 357 of the Cornell University Station and also by Table 58. Table 55 gives the cost for each of the 53 farms surveyed. In Table 56 the farms are grouped according to the distance the milk is carried. While there is not a progressive increase in cost per hundredweight from group to group, there is so for the ¼- to 1- to 2- to 3- to 4-mile groups, which illustrates the tendency for the cost of transportation to increase with the distance. Table 58 shows that it costs more for the farmer to haul his own milk than to hire it done.

Table 55.—Cost of Teaming Milk on 53 Farms in Jefferson County, New York (Hopper and Robertson)

| Herd number | Number of cows | Pounds of milk teamed | Miles teamed | Cost of man labor for teaming | Cost of horse labor for teaming | Cost of teaming 100 lb. of milk |
|---|---|---|---|---|---|---|
| 3 | 49 | 338,984 | 0.25 | $54.75 | $87.60 | $0.042 |
| 32 | 28 | 230,557 | 0.25 | 27.45 | 21.96 | 0.021 |
| 30 | 24 | 153,867 | 0.25 | 27.30 | 43.80 | 0.046 |
| 18 | 10 | 86,335 | 0.25 | 21.75 | 34.80 | 0.066 |
| 36 | 10 | 77,394 | 0.25 | 31.50 | 25.20 | 0.073 |
| 48 | 13 | 122,293 | 0.50 | 54.75 | 43.80 | 0.081 |
| 45 | 14 | 113,538 | 0.50 | 45.00 | 72.00 | 0.103 |
| 47 | 17 | 168,406 | 1.00 | 23.75 | 27.00 | 0.030 |
| 20 | 13 | 166,011 | 1.00 | 54.75 | 87.60 | 0.086 |
| 35 | 11 | 123,458 | 1.00 | 54.75 | 43.80 | 0.080 |
| 19 | 15 | 114,958 | 1.00 | 30.30 | 48.48 | 0.069 |
| 28 | 12 | 90,091 | 1.00 | 54.75 | 87.60 | 0.158 |
| 53 | 14 | 88,489 | 1.00 | 54.75 | 87.60 | 0.161 |
| 16 | 7 | 86,420 | 1.00 | 54.75 | 43.80 | 0.114 |
| 8 | 11 | 78,146 | 1.00 | 18.75 | 15.00 | 0.043 |
| 40 | 6 | 57,171 | 1.00 | 54.75 | 43.80 | 0.131 |
| 37 | 8 | 51,496 | 1.25 | 27.30 | 43.80 | 0.138 |
| 50 | 24 | 196,995 | 1.50 | 49.50 | 59.40 | 0.055 |
| 17 | 10 | 147,434 | 1.50 | 21.30 | 25.56 | 0.032 |
| 49 | 20 | 125,774 | 1.50 | 40.95 | 32.76 | 0.059 |
| 42 | 11 | 113,178 | 1.50 | 36.55 | 56.88 | 0.083 |
| 12 | 11 | 96,886 | 1.50 | 27.15 | 43.44 | 0.073 |
| 11 | 12 | 72,683 | 1.50 | 27.30 | 21.84 | 0.068 |
| 46 | 5 | 51,974 | 1.50 | 42.75 | 68.40 | 0.214 |
| 27 | 24 | 208,447 | 2.00 | 56.25 | 90.00 | 0.070 |
| 1 | 24 | 152,718 | 2.00 | 81.00 | 64.80 | 0.105 |
| 14 | 19 | 138,137 | 2.00 | 109.50 | 175.20 | 0.206 |
| 34 | 14 | 77,278 | 2.00 | 22.80 | 36.48 | 0.077 |
| 9 | 12 | 62,478 | 2.00 | 36.15 | 28.92 | 0.104 |
| 39 | 8 | 59,562 | 2.00 | 57.30 | 45.82 | 0.173 |
| 5 | 23 | 186,521 | 2.50 | 40.95 | 65.52 | 0.057 |
| 6 | 19 | 132,532 | 2.50 | 81.90 | 131.04 | 0.154 |
| 51 | 17 | 104,162 | 2.50 | 42.00 | 67.20 | 0.105 |
| 43 | 12 | 69,310 | 2.50 | 40.50 | 43.20 | 0.121 |
| 25 | 23 | 240,637 | 3.00 | 90.00 | 144.00 | 0.097 |
| 15 | 14 | 134,970 | 3.00 | 54.60 | 87.36 | 0.105 |
| 31 | 17 | 125,858 | 3.00 | 135.00 | 216.00 | 0.279 |
| 10 | 15 | 124,793 | 3.00 | 136.50 | 218.40 | 0.284 |
| 52 | 24 | 119,174 | 3.00 | 62.10 | 99.36 | 0.135 |
| 24 | 18 | 102,550 | 3.00 | 164.25 | 262.80 | 0.416 |
| 33 | 11 | 100,371 | 3.00 | 51.00 | 93.60 | 0.144 |
| 22 | 14 | 82,485 | 3.00 | 68.25 | 109.20 | 0.215 |
| 38 | 9 | 45,577 | 3.00 | ...... | ...... | 0.156 |
| 44 | 18 | 107,981 | 3.50 | 144.00 | 230.40 | 0.347 |
| 23 | 22 | 244,820 | 4.00 | 135.00 | 216.00 | 0.143 |
| 29 | 12 | 168,495 | 4.00 | 136.87 | 219.00 | 0.211 |
| 41 | 27 | 164,070 | 4.00 | 54.00 | 43.20 | 0.059 |
| 7 | 22 | 133,826 | 4.00 | 117.00 | 187.20 | 0.227 |
| 4 | 15 | 114,228 | 4.00 | 49.50 | 79.20 | 0.113 |
| 21 | 9 | 106,875 | 4.00 | 83.25 | 133.20 | 0.203 |
| 2 | 7 | 61,760 | 4.00 | 49.50 | 79.20 | 0.208 |
| 26 | 17 | 119,360 | 5.00 | 82.35 | 131.76 | 0.179 |
| 13 | 13 | 116,579 | 5.00 | 42.75 | 68.40 | 0.095 |
| **Total, 53** | 834 | 6,582,183 | 113.50 | $3,160.87 | $4,532.38 | |

TABLE 56.—COST OF TEAMING MILK ON 53 FARMS IN JEFFERSON COUNTY, NEW YORK (HOPPER AND ROBERTSON)

| Number of herds | Average number of pounds of milk per farm | Number of miles teamed | Average cost of man labor | Average cost of horse labor | Cost of teaming per hundredweight of milk |
|---|---|---|---|---|---|
| 5 | 177,827 | 0.25 | $32.55 | $42.67 | $0.042 |
| 2 | 117,916 | 0.50 | 49.88 | 57.90 | 0.091 |
| 9 | 110,128 | 1.00 | 44.59 | 53.85 | 0.089 |
| 1 | 51,496 | 1.25 | 27.30 | 43.80 | 0.138 |
| 7 | 114,989 | 1.50 | 35.07 | 44.04 | 0.069 |
| 6 | 116,437 | 2.00 | 60.50 | 73.54 | 0.115 |
| 4 | 123,131 | 2.50 | 51.34 | 76.74 | 0.104 |
| 8 | 180,109 | 3.00 | 95.21 | 153.84 | 0.138 |
| 1 | 107,981 | 3.50 | 144.00 | 230.40 | 0.347 |
| 7 | 142,010 | 4.00 | 89.30 | 136.71 | 0.159 |
| 2 | 117,970 | 5.00 | 62.55 | 100.08 | 0.138 |

TABLE 57.—TEAMING COSTS PER FARM, 6,582,183 LB. OF MILK ON 53 FARMS JEFFERSON COUNTY, NEW YORK (HOPPER AND ROBERTSON)

| | Number of hours yearly | Cost | Cost per hundredweight of milk |
|---|---|---|---|
| Man labor | 398 | $59.64 | $0.048 |
| Horse labor | 713 | 85.52 | 0.069 |
| Total | 1,111 | 145.16 | 0.117 |

Average length of haul, 2.14 miles.
Rate per mile per hundredweight, $0.055.

TABLE 58.—COST OF HAULING MILK FROM 148 FARMS IN DELAWARE COUNTY, NEW YORK TO CREAMERY (WARREN)

| Number of miles from creamery | Milk hired hauled | | Milk hauled by farmer | |
|---|---|---|---|---|
| | Number of farms | Cost for each dollar's worth of milk | Number of farms | Cost for each dollar's worth of milk |
| 0.5 | .. | ...... | 19 | $0.047 |
| 1.0 | 3 | $0.043 | 16 | 0.064 |
| 2.0 | 12 | 0.042 | 13 | 0.066 |
| 3.0 | 18 | 0.055 | 6 | 0.097 |
| 4.0 | 12 | 0.061 | 5 | 0.155 |
| 5–6 | 24 | 0.060 | 3 | 0.138 |
| 7–8 | 9 | 0.065 | .. | ...... |
| 9–10 | 4 | 0.068 | 3 | 0.199 |
| 13.0 | 1 | 0.068 | .. | ...... |

A farmer's time counted at 15 cts. per hour.

A boy's time counted at 8 cts. per hour.

A team's time counted at 15 cts. per hour or 8 cts. per horse per hour. The time taken to get ready and to hitch up as well as the small size of the load makes the cost to the farmer of hauling his own milk very high.

A charge of 15 cts. per man and 12 cts. per horse was made and the cost of teaming the milk for each herd was calculated from all the milk hauled from each farm during the year and the number of men and horse hours required to move the year's product of milk to the factory or station.

**Temperature and Bacteria of Milk Increase in Hauling.**—Since bacteria multiply rapidly in milk at temperatures above 50°F. and since the rate of increase is greater the higher the temperature, the tendency for milk to warm up in transportation is a serious matter. The U. S. Department of Agriculture in some experiments found that when milk, cooled to 50°F., was hauled in an open truck 13 miles on a bright sunny day with the temperature at 82.6°F., in 3 hr., cans covered with hair-quilt-jackets showed a rise in temperature of 5.5°, those wrapped in wet burlap 8.5° and unprotected cans 28.5°F. At Milwaukee, Gunn studied this question and some of the measurements made by him are set forth in Table 59.

TABLE 59.—RISE IN TEMPERATURE OF MILK COLLECTED BY WHOLESALE WAGONS IN MILWAUKEE, WIS., AUG. 30, 1911 (GUNN)

| Shippers' numbers | Place of collection | Time collected, a.m. | Time delivered | Temperature of milk at collection, °F. | Temperature of milk at delivery, °F. |
|---|---|---|---|---|---|
| 1 | Farm at roadside | 6:30 | 1:05 | 56 | 64 |
| 4 | Cold water tank at farm | 6:35 | 11:30 | 52 | 58 |
| 5 | From farmer at roadside | 6:50 | 12:30 | 57 | 62 |
| 6 | Cold water tank at farm | 6:55 | 12:50 | 56 | 60 |
| 7 | Cold water tank at farm | 6:55 | 12:15 | 60 | 62 |
| 8 | From farmer at roadside | 7:00 | 12:50 | 56 | 62 |
| 10 | From farmer at roadside | 7:15 | 11:30 | 45 | 56 |
| 11 | From farmer at roadside | 7:20 | 11:20 | 53 | 58 |
| 12 | From farmer at roadside | 7:20 | 11:20 | 48 | 60 |
| 14 | From farmer at roadside | 7:25 | 11:45 | 61 | 63 |
| 15 | Cold water tank at farm | 7:30 | 12:00 | 56 | 62 |
| 17 | From roadside (unprotected) | 7:35 | 12:00 | 58 | 60 |
| 18 | From farmer at roadside | 7:40 | 11:45 | 59 | 56 |
| 19 | From farmer at roadside | 8:10 | 12:15 | 60 | 62 |
| 20 | Cold water tank at farm | 8:20 | 12:15 | 56 | 60 |
| 21 | Cold water tank at farm | 8:40 | 12:00 | 59 | 62 |
| 22 | Cold water tank at farm | 8:45 | 12:30 | 60 | 60 |
| 25 | Cold water tank at farm | 9:40 | 12:30 | 64 | 64 |

Air temperature at first collection, 50°F.
Air temperature at last delivery, 70°F.
Total miles traveled to city limits, 16.
Total time consumed on trip, 5 hr., 35 min.

At Springfield, Mass., Gamble studied the relationship between the temperature at which milk is transported and the bacterial count. In

every case the milk was hauled about 15 miles, an uncovered wagon being used in 1910, and a covered one in 1911 and 1912. On Aug. 23, 1910, he took the temperatures of 20 samples from twenty 10-qt. cans coming from the different dairies and on July 27, 1911, and July 23, 1912, under similar atmospheric and other conditions he again took temperatures and samples of the 10-qt. cans of these same dairies. The counts, Table 60 shows, were markedly lower in 1911 and 1912, when the temperatures of the milk were held between 44° and 46°F., than they were in 1910, when the temperature ranged from 56° and 64°F.

TABLE 60.—TEMPERATURE AND BACTERIAL COUNT OF THE MILK OF 20 DAIRIES IN SPRINGFIELD, MASS. (GAMBLE)

| Dairy number | Aug. 23, 1910 | | July 27, 1911 | | July 23, 1912 | |
|---|---|---|---|---|---|---|
| | Temperature | Count | Temperature | Count | Temperature | Count |
| 1 | 64 | 70,000 | 46 | 10,000 | 44 | 31,000 |
| 2 | 64 | 20,000 | 46 | 370,000 | 44 | 40,000 |
| 3 | 64 | 320,000 | 46 | 400,000 | 44 | 30,000 |
| 4 | 64 | 50,000 | 46 | 10,000 | 44 | 30,000 |
| 5 | 64 | 460,000 | 46 | 140,000 | 44 | 20,000 |
| 6 | 64 | 130,000 | 46 | 27,000 | 44 | 28,500 |
| 7 | 64 | 110,000 | 46 | 60,000 | 44 | 170,000 |
| 8 | 64 | 10,000 | 46 | 50,000 | 44 | 45,000 |
| 9 | 64 | 400,000 | 46 | 250,000 | 44 | 24,000 |
| 10 | 64 | 160,000 | 46 | 10,000 | 44 | 28,000 |
| 11 | 64 | 2,000,000 | 46 | 40,000 | 44 | 18,000 |
| 12 | 64 | 6,000,000 | 46 | 460,000 | 44 | 42,000 |
| 13 | 64 | 40,000 | 46 | 30,000 | 44 | 130,000 |
| 14 | 64 | 1,200,000 | 46 | 10,000 | 44 | 20,000 |
| 15 | 56 | 80,000 | 46 | 10,000 | 44 | 5,000 |
| 16 | 56 | 330,000 | 46 | 40,000 | 44 | 17,000 |
| 17 | 56 | 70,000 | 46 | 40,000 | 44 | 40,000 |
| 18 | 56 | 20,000 | 46 | 140,000 | 44 | 70,000 |
| 19 | 56 | 60,000 | 46 | 50,000 | Discontinued sending | |
| 20 | 56 | 10,000 | 46 | 460,000 | Discontinued sending | |
| Average | 62 | 570,000 | 46 | 130,350 | 44 | 46,600 |

To show where the increase in the bacterial count between the farm and the consumer takes place, Gamble made a bacterial count of samples of milk drawn from 10-qt. cans in the milk tanks at 18 different farms. Each can was marked and after it had cooled 1½ hr. in the tank of the city dealer it was again sampled. The 18 cans were then poured over and from each one of them a quart bottle was filled. These 18 quart bottles were then handled in a routine way along with the other milk then being bottled preparatory to being loaded on the delivery wagons and delivered to consumers, and they were delivered and exposed to the air along with

the other milk. The next morning the bottles were placed in an ice box and bacteria samples were plated from them. Table 61 gives the results of the experiment. The average temperature of the milk at the farms was higher than the average temperature of the milk after 5 hr. transportation and 1½ hr. in the ice tanks of the dealer. The average temperature of the milk in the bottles, when placed in the ice box at 7:00 next morning, was 14°F. higher than when it left the tanks of the dealer. The increase in bacteria between the dealer and consumer was six times as great as the increase between the farm and the dealer's tanks.

Table 61.—Bacterial Increase That Occurs in Milk between Dairy Farm and Milk Plant as Compared with That Which Occurs between Milk Plant and Consumer (Gamble)

| Dairy number | Temperature °F. at farm | Count | Temperature °F. at dealer | Count | Temperature °F. at consumer | Count |
|---|---|---|---|---|---|---|
| 1 | 42 | 6,200 | 44 | 40,000 | 58 | 130,000 |
| 2 | 50 | 27,000 | 44 | 70,000 | 58 | 120,000 |
| 3 | 56 | 24,600 | 44 | 180,000 | 58 | 800,000 |
| 4 | 50 | 1,100 | 44 | 5,200 | 58 | 10,000 |
| 5 | 48 | 9,200 | 44 | 40,000 | 58 | 80,000 |
| 6 | 44 | 3,600 | 44 | 28,000 | 58 | 50,000 |
| 7 | 48 | 8,000 | 44 | 20,000 | 58 | 110,000 |
| 8 | 46 | 15,600 | 44 | 24,000 | 58 | 70,000 |
| 9 | 44 | 3,800 | 44 | 30,000 | 58 | 60,000 |
| 10 | 50 | 9,400 | 44 | 28,600 | 58 | 210,000 |
| 11 | 46 | 100,000 | 44 | 130,000 | 58 | 240,000 |
| 12 | 50 | 3,400 | 44 | 17,000 | 58 | 120,000 |
| 13 | 70 | 70,000(?) | 44 | 45,600 | 58 | 180,000 |
| 14 | 40 | 5,900 | 44 | 31,000 | 58 | 140,000 |
| 15 | 42 | 9,800 | 44 | 42,000 | 58 | 80,000 |
| 16 | 44 | 18,000 | 44 | 30,000 | 58 | 800,000 |
| 17 | 44 | 10,000 | 44 | 20,000 | 58 | 80,000 |
| 18 | 48 | 43,000 | 44 | 170,000 | 58 | 3,200,000 |
| Average | 46.8 | 20,400 | 44 | 52,800 | 58 | 360,000 |

In some of the important cities of the country, as for instance Richmond, Va., practically all of the milk is hauled by wagon into the city; in others like Chicago and Cleveland none of the milk is handled in this way. Between these extremes are Milwaukee which so receives 40 per cent., New Orleans 35 per cent., Detroit 17 per cent., Baltimore 17 per cent., Boston 9 per cent., Philadelphia 4 per cent., Indianapolis 4 per cent. and New York 1 per cent.

**Use of Auto Truck in Hauling Milk from Farm to City.**—The auto truck is being used more and more in bringing milk from outlying farms

to the city. Thus Indianapolis gets 3 per cent. of its supply, Cleveland 5 per cent., Philadelphia 5 per cent., Baltimore 7 per cent. and Detroit 8 per cent. in this manner.

**Transportation of Milk by Steamboat.**—Steamboats are little used for carrying milk; Chicago gets a small quantity of milk that way in the summer months and New York so receives 6,000 qt. daily which is about 0.2 per cent. of the entire daily supply.

**Transportation of Milk by Electric Cars.**—Electric railroads transport great quantities of milk. The amount of milk that a city receives by electric roads depends on the degree to which interurban traction systems have been developed in its vicinity. In this respect the cities

*Courtesy of the Polk Sanitary Milk Co.*

FIG. 33.—Trolley shipping station, at Mooresville, Indiana, in the Indianapolis dairy district.

of the middle west are well-served. Chicago receives 5 per cent. of its supply over electric roads, Detroit 39 per cent., Cleveland 45 per cent., Indianapolis 68 per cent., whereas of the Eastern cities Philadelphia receives only 4 per cent. in this way and Boston, New York and Baltimore none at all. In some cases the electric roads have made special effort to capture the milk-carrying trade and have established highly commendable service. Often, however, nothing of the sort is attempted and the milk is handled very carelessly. Trainmen drink from the unsealed cans and the milk travels on platforms in the sun or is stowed away among a miscellaneous parcel of baggage that is often dirty and smelly. The stations where the milk is picked up are usually uncovered platforms where it is often left exposed to the elements for an hour or more before being loaded onto the cars. Such conditions are wholly unnecessary and would hardly be permitted in a district where there

are live milk inspectors. Table 62 shows the results of some observations by Gunn on the temperature of milk picked up at electric car stations, en route to Milwaukee. They are briefly, that at an air temperature of 80°F., out of 84 separate shipments of milk, 1.2 per cent. gave temperature readings between 45° and 49°F., 23.8 per cent. between 50° and 59°F., 55.9 per cent. between 60° and 69°F., 17.9 per cent. between 70° and 79°F., or in other words 85.7 per cent. of the milk was at a temperature favorable for bacterial multiplication.

Table 62.—Collection of Milk by Electric Railway (Gunn)
Showing Temperature of Milk at Time of Collection

| Station | Time, a.m. | Temperature of milk in °F. when picked up by train. Each temperature reading is on the milk of a single shipper |
|---|---|---|
| Port Wash. | 8:25 | 67, 63, 64, 66 |
| 24.0 | 8:30 | 69, 69 |
| 23.0 | 8:35 | 70, 64 |
| 22.0 | 8:50 | 82, 76 |
| 21.0 | 9:00 | 68, 78 |
| 18.0 | 9:15 | 78, 70, 67, 50, 68, 66, 48, 66, 78, 69, 56, 76, 67, 67 |
| 17.0 | 9:20 | 68, 70, 72 |
| 16.5 | 9:30 | 60, 58, 64, 66, 56, 64, 50, 52, 64, 66, 64, 70 |
| 16.0 | 9:50 | 66, 59, 65, 66, 56, 76, 56, 54, 64, 50, 60, 50, 50, 66 |
| 15.0 | 9:55 | 66, 50, 64, 65, 66, 50, 50, 50, 70, 71, 73, 67 |
| 14.0 | 10:00 | 66 |
| Thiensville | 10:05 | 67, 67, 56, 55, 64, 66, 65 |
| Mequon | 10:10 | 58, 66, 68, 64 |
| 9.0 | 10:20 | 68, 70, 56, 66 |
| 8.0 | 10:23 | 66 |

Air temperature at start, 80°. Distance traveled, 30 miles.
Air temperature at finish, 88°. Time taken for trip, 2 hr.

**Transportation of Milk by Steam Railroads.**—In the smaller cities and towns all the milk is brought in by wagons, but as the cities grow their principal sources of milk supply are located further and further away and more and more of the milk comes by steamboat, electric railways and steam railroads. It is estimated that about 5 per cent. of the milk supply of Indianapolis, 35 per cent. of that of Detroit, 50 per cent. of that of Washington, 55 per cent. of that of Cleveland, 60 per cent. of that of Milwaukee and of that of San Francisco, 65 per cent. of that of New Orleans, 75 per cent. of that of Baltimore, of Cincinnati and St. Louis, 83 per cent. of that of Philadelphia, 90 per cent. of that of Boston, 95 per cent. of that of Chicago and 98 per cent. of that of New York is brought to the city by steam railroad.

The first railroad in the United States was built in 1825; from that time till the latter part of 1829 the cars were moved by horses. At that date the steam engine was introduced and thereafter steam railroading

developed rapidly. It is probable that the shipment of milk by steam began in a small way. Thus, H. N. Woolman has stated that in 1855 his family moved to 34th and Bridge Streets, now Spring Garden, Philadelphia, and shipped milk to the city on the front platform of a passenger car. This was the first milk shipped over the Philadelphia and West Chester Railroad. Whitaker states that Boston was probably the first city in the United States to transport milk by railroad, the first shipment being made over the Boston and Worcester Railroad in April, 1838, by Jason Chamberlain. He sold milk at 25 cts. per can of 9½ qt. Later he sold his milk business to Rufus Whiting. The milk was shipped by express in a baggage car. The first milk car was run soon after between Westboro and Boston by a company of peddlers. Later the Boston Milk Co. ran a milk car to Cordaville and still later Rowell and Kelly brought in milk from Northboro and Fayville. In 1843 the *New England Farmer* stated that a single dealer brought to Boston over the Worcester Railroad 200,000 gal. of milk a year which was estimated to be 10 per cent. of the city's entire supply. The milk brought 20 cts. a gallon. As the population of Boston was 100,000 there was a per capita consumption of a trifle less than ½ pt. a day. The milk that came over the Boston and Worcester Railroad entered the south side of the city. On the north side, too, a milk business was built up; milk was brought from Concord, Mass., and from Wilton, N. H. Business at the latter place passed into the hands of David Whiting in 1857.

An article reprinted from the *Albany Cultivator* by the *New England Farmer* of Sept. 6, 1843, tells how the growth of railroads had made it possible to ship milk a distance of 50 miles to the cities and have it arrive in good condition. It states that the effect of this was first felt in Boston when milk was improved in quality and reduced in price and it says further that New York City was beginning to receive the benefits of milk shipped by rail from the country. Merritt states that prior to 1870 all of the milk consumed in Boston came from a distance of not more than 65 miles. By 1890 the Boston and Maine was bringing milk from a distance of 150 miles and in 1910 of 275 miles. Prior to 1900 all the milk for Boston carried by the New York, New Haven and Hartford Railroad came from stations within 34 miles of the city but in 1900 the furthest shipping points were 85 miles distant; in 1910 they were 211 miles.

The first train in New York State that was classed as a milk train was run over the Erie Railroad from Orange County to New York City in 1847.

Merritt says that:

"Prior to 1842 practically all milk consumed in New York City was brought in by wagons from the surrounding counties. In 1842 when the Erie was under construction one dealer shipped from Orange County.

"In a few years the Harlem division of the New York Central began to haul milk from the counties on the west bank of the Hudson; at the same time the Newburgh, Dutchess and Connecticut branch of the Central New England was shipping milk to New York City over the Hudson River branch of the New York Central. A few years later the New York, New Haven and Hartford was bringing milk from the New England States to supply the New York City market. In 1870 the Delaware, Lackawanna and Western received small consignments of milk on the Sussex branch in New Jersey and in the same year the New York Central and Western started its first milk train from Bloomingburg, N. Y. Practically all of the railroads had their farthest point from New York within the 100-mile limit except that the Harlem was bringing milk from Rutland, Vt., a distance of 240 miles. There was very little change in the areas from which milk was obtained until 1890. In that year the New York Ontario and Western extended its service to Walton, N. Y., a distance of 179 miles, shortly after 1890 several other railroads started milk trains. The Lehigh Valley established this service with Dryden, N. Y., as a terminus. In 1893 the Delaware and Hudson was receiving milk and forwarding it to New York City over the Delaware, Lackawanna and Western. In 1890 the West Shore extended its service beyond Albany with Syracuse as a starting point, and 2 years later the Hudson River branch of the New York Central extended its service to the same point. By 1910 many of the points from which milk was shipped to New York City were over 300 miles distant. Table 63 shows the growth of the business on the principal railroad lines."

TABLE 63.—NUMBER OF MILLION GALLONS OF MILK AND CREAM RECEIVED AT NEW YORK CITY (MERRITT)

(Cream not reduced to terms of milk)

| Railroad | 1885–89 | 1890–94 | 1895–99 | 1900–04 | 1904–09 | Total |
|---|---|---|---|---|---|---|
| New York Central | 14.0 | 12.3 | 10.1 | 23.2 | 36.1 | |
| Delaware, Lackawanna & Western | 2.1 | 12.0 | 20.0 | 17.9 | 25.3 | |
| Erie | 15.0 | 17.0 | 15.9 | 18.2 | 23.6 | |
| New York Ontario & Western | 6.0 | 9.9 | 14.6 | 18.2 | 22.2 | |
| Lehigh Valley | .... | 0.5 | 3.0 | 7.1 | 13.3 | |
| West Shore | 3.0 | 5.1 | 6.4 | 6.8 | 8.5 | |
| New York, Susquehanna & Western | 5.1 | 5.9 | 7.0 | 7.6 | 7.7 | |
| New York, New Haven & Hartford | 3.9 | 2.4 | 4.2 | 4.3 | 6.0 | |
| Ramsdell Boat Line | 1.5 | 2.7 | 2.6 | 2.5 | 1.7 | |
| Central R. R. of New Jersey | 1.8 | 1.0 | 1.0 | 0.7 | 0.4 | |
| Long Island R. R. | 1.5 | 1.1 | 0.3 | .... | .... | |
| Other sources | 3.3 | 2.4 | 2.2 | 2.2 | 2.3 | |
| Total | 57.3 | 72.3 | 87.2 | 108.8 | 147.2 | |

**Philadelphia.**—"Prior to 1870 Philadelphia was receiving its milk from an area within a radius of 50 miles of the city and the greater part of the milk received was transported by the railroad. Prior to 1910 the farthest points on the Pennsylvania System from which milk was shipped to Philadelphia were near

Harrisburg and Reading in Pennsylvania, and Milford, Princeton, Hightstown, Bridgeton and Salem in New Jersey. But in 1911 the area was extended until it reached points in New York State within a few miles of Buffalo. In 1910 the Reading System was drawing its milk for Philadelphia over practically as large an area as was the Pennsylvania.

"Table 64 shows the growth of the business of shipping milk by railroad to Philadelphia."

TABLE 64.—GROWTH OF RAILROAD MILK BUSINESS IN PHILADELPHIA (MERRITT)
(Number of million gallons of milk received in Philadelphia)

| Railroad | 1890–94 | 1895–99 | 1900–04 | 1905–09 |
|---|---|---|---|---|
| Pennsylvania System | 9.4 | 9.6 | 11.2 | 14.2 |
| Philadelphia and Reading R. R. | 9.1 | 8.8 | 9.6 | 12.6 |
| Baltimore & Ohio R. R. | 1.4 | 1.6 | 1.6 | 2.6 |
| Wagons | 2.6 | 2.1 | 1.7 | 1.5 |
| Trolley lines at 63d and Market Streets | .... | .... | .... | 1.2 |
| Lehigh Valley R. R. via Philadelphia & Reading R. R. | 0.5 | 2.0 | 2.5 | 0.8 |
| Adams Express Co. | .... | .... | .... | 0.5 |
| U. S. Express Co. | .... | .... | .... | 0.1 |
| Total | 23.1 | 24.0 | 26.7 | 33.6 |

In the United States, the shipment of milk by steam railways increased steadily and milk trains became part of the regular business equipment of all railroads tapping the dairy districts. Though the percentage of milk that was brought in by rail increased steadily, consumers were long prejudiced against railroad milk for much of it was produced in an insanitary way, was carelessly handled in transit and was not properly cared for by the contractors who sold it. In many cities dairies persisted within the city limits and in the suburbs. In some cases a considerable percentage of the milk came from slop dairies. Thus in Boston they were forbidden in 1859, but in New York they were not prohibited till 1873. As late as the 90's probably most of the milk came from distances of not greater than 100 miles but with the growth of the cities and the advent of improved methods in producing the milk and shipping it and the development of proper facilities for handling it, milk has come from greater and greater distances and in better condition till now daily shipments are made from dairy districts 200 to 400 miles away.

**Some Economic Features of Transportation of Milk by Railroad.**—Harbison has outlined some features of the transportation of milk by rail. "It moves every day in the year and in such regular quantities that the maximum of use and economy is obtained from a limited amount of railroad equipment. This is in marked contrast to the movement of grain and many other commodities which is very heavy at some seasons

and very light at others. The facilities for milk require comparatively little capital. The country loading platforms are very simple and inexpensive; the terminals are mostly wooden sheds without sides, and with a minimum of platform space. As the milk must be removed immediately after arrival in the city, expensive storage warehouses in congested districts are not required. The cars that are used in carrying milk are mostly old ones that have been diverted from other purposes. The traffic is so regular that only a minimum of rolling stock is necessary to care for fluctuations in business. The cars are promptly released at the terminals and on arrival in the country are loaded forthwith."

"Most cars make a round trip daily. The labor cost of handling the business is low for in the country the shippers load their own milk and

*From the* 40th *Annual Report of the Health Department of the City of Boston.*

FIG. 34.—A railroad receiving station in Vermont that protects the milk from sun and storm.

in the city the dealers help unload. The contractors accept delivery at terminals selected by the carrier; very little milk is delivered at passenger terminals. So much milk comes out of a dairy district that it can usually be carried in trainload lots which makes the traffic desirable. Milk is a necessity therefore it should have the benefit of the accepted traffic principle that agricultural necessities should be carried at the lowest tariffs consistent with a reasonably profitable return on the capital employed in moving them. Despite this there is some evidence of a tendency for the railroads to increase the rates."

In general the milk that is shipped by rail is handled in cans which under the best practice are washed and sterilized in the cities and returned to the farmer who fills them with milk and carries them to the

train. Sometimes milk is delivered at the cars by a general collector for a district and in some places the cases are filled at the siding of a creamery which has received the milk from the farmer, cooled, standardized, pasteurized and recanned it. A considerable percentage of the milk of some cities, notably Chicago, is shipped from country milk plants ready for delivery. In most cases it is the intention of the farmer to deliver the milk at the station platform shortly before the train is scheduled to leave but the milk is often left exposed for a long time both at points where it is picked up and at which it is delivered. Kelly tells of an instance that came under his observation where a shipment of milk that was not refrigerated in transportation arrived at the city terminal with a temperature of 65°F. and was unloaded onto an uncovered platform where half of it remained over an hour and a half acquiring a temperature of 85 to 90°F. Such occurrences are far from exceptional.

**Temperature of Milk in Transit by Rail.**—This question of keeping the milk in transit from the country to the city at low temperature is important. The board of health of Baltimore, Md., in 1911 made a special investigation of conditions under which milk was shipped by rail to that city. Temperatures of 79 shipments of milk were taken as soon as they were loaded on the cars, and again when the train reached the city. No means of cooling the cars or the milk was provided and the temperature of the cars ranged from 69° to 71°F. The time occupied in bringing milk from the most distant shipping station was 2 hr. and 15 min. A summary of the observation appears in Table 65.

TABLE 65.—TEMPERATURE OF MILK WHEN LOADED ABOARD RAILROAD CARS AT COUNTRY SHIPPING STATION AND ON ARRIVAL AT TERMINALS IN BALTIMORE, MD. (THOMAS)

| Temperature of car | Railroad A. 71°F. | Railroad B. 70°–71°F. | Railroad C. 69°–71°F. |
|---|---|---|---|
| Time of first temperature | 6:40 a.m. | 6:30 a.m. | 6:45 a.m. |
| Time of final temperature | 8:40–9.00 | 8:45–9:00 | 8:10–8:25 |
| Average initial temperature | 64.7° | 59.6° | 62.2° |
| Average final temperature | 66.5° | 62.8° | 64.1° |
| Average rise in temperature | 1.8° | 3.9° | 2.4° |
| Maximum initial temperature | 86.5° | 75.2° | 77.0° |
| Maximum final temperature | 82.5° | 73.0° | 76.0° |
| Minimum initial temperature | 46.0° | 44.7° | 58.0° |
| Minimum final temperature | 54.5° | 52.0° | 61.0° |
| Maximum rise in temperature | 8.5° | 7.3° | 4.0° |
| Minimum rise in temperature | −4.0° | −2.2° | −5.0° |

The shipments showing the maximum initial temperatures had also the maximum final temperatures, as would be expected, and showed the minimum rise in temperature, this being in each case a negative quantity,

that is, the milk became cooler, since the original temperature was higher than that of the car and of the surrounding cans. Likewise the shipments showing the minimum initial temperatures had also the minimum final temperatures, but showed the maximum rise in temperature. The cans were closely packed in the car, and the temperature of the car had, in most cases, but little effect upon the temperature of the milk.

Sharwell followed four cans of milk from Baldwinsville, N. Y., to Newark, N. J., a distance of 340 miles. The milk was produced in four barns three of which had scores of between 65 and 70; they were fairly clean but the cows' udders were not wiped off nor were small-top milk pails used. The fourth barn scored but 55 and was very dirty as was the method of handling the milk. None of the dairies had milk houses nor was the milk cooled. The milk was set alongside the road to be picked up by a truckman who carried it to the creamery. On its arrival there the milk was thrown into a receiving vat, run over a cooler and was caught in its original can which on being filled was put in a concrete tank, containing water and floating ice, to cool. In handling the milk at the creamery no pains were taken to protect it from contamination. The car on which the milk was shipped is iced once in a round trip of 680 miles. At the beginning of the journey the car, though there were only 50 lb. of ice in the bunkers, had a temperature of 50°F. because of the coolness of the milk and the chunks of ice put on top of the cans. The

Table 66.—Increase in Bacterial Content of Milk in Transit by Railroad from Baldwinsville, N. Y., to Newark, N. J. (Sharwell)

| | Bacteria per cubic centimeter in the milk of the four cans | Remarks |
|---|---|---|
| Temperature in °F of the four cans of milk on arrival at the creamery, 88°, 86°, 86°, 84° | | |
| When put aboard the car, 50° | A. 5,400,000<br>B. 5,400,000<br>C. 4,500,000<br>D. 1,530,000 | Average count of the four cans as the milk left the creamery, 4,207,500 bacteria per cubic centimeter. |
| At Binghamton | A. 9,000,000<br>B. 7,700,000<br>C. 13,700,000<br>D. 16,000,000 | Average bacterial count of the four cans after 7 hr. travel, 11,600,000 bacteria per cubic centimeter. |
| At Newark, 55°, 56°, 56°, 58° | A. 19,300,000<br>B. 15,700,000<br>C. 18,000,000<br>D. 25,000,000 | Average bacterial count of the four cans, 19,500,000 bacteria per cubic centimeter. |
| Half emptied cans in shops | A. 19,900,000<br>B. 34,000,000<br>C. 75,000,000<br>D. 68,000,000 | Average bacterial count of the four cans, 49,475,000 bacteria per cubic centimeter. |

temperature gradually rose to 65°F. The car was iced at noon at Chenango Forks and as Mr. Sharwell left the train at Binghamton the effect of the icing can only be judged by the fact that when the milk arrived in Newark three of the cans had a temperature of 56°F. and one of 58°F. From the terminal the four cans were taken to four shops where the milk was sold as "loose" milk; the bacterial content of the milk was tested when the cans were half empty. The increase in bacteria in each of the four cans of milk in the course of the journey from the farm to the shops is shown in Table 66.

**Types of Cars Used in Transporting Milk.**—The cars in which milk is carried are of different construction. Small shipments often go in baggage or express cars.

*Courtesy of J. O. Jordan.*

FIG. 35.—Office of old style New England milk car.

None of the refrigerator cars used are designed to cool the milk in transit; they merely hold the milk at about the temperature it has when put aboard. There are two types of refrigerator cars in common use. One is the ordinary baggage type of car that has little or no insulation and so is used for short hauls. The cans are set on the floors and in hot weather have crushed ice packed around them. As the ice melts the water runs out at the doors or through cracks in the floors. The other

has ice bunkers or brine tanks in the ends of the cars and a ratio of ice to loading capacity of about 1 to 11 cu. ft. In some of the more recent cars a mixture of salt and ice is used to obtain lower temperature than can be had with ice alone.

Whitaker described the milk cars in use in New England in 1905 as being 48 ft. long, inside measurement, and in the center having an office 8½ by 9 ft. This was provided with two windows on each side. In each car were eight closets, each 3¼ by 4 ft. and with two shelves accommodating three tiers of 8½-qt. cans, the capacity of each closet being

*Courtesy of J. O. Jordan.*

Fig. 36.—Old style car used for transporting milk in New England, showing cans on floor and in closet, and clerk in office.

90 cans, making the total capacity of the car 720 cans. There were two doors, 3½ ft. wide, opening to a space in each end of the car for receiving the cans, storing and breaking ice and for handling the cans. As the floor space in the closets was utilized the usual carload was 960 cans. This type of car has all but disappeared; the cars have been rebuilt so that they have an office in the middle on both sides of which the milk is stored. They have a capacity of 1,050 8½-qt. cans. The type of car that is in ordinary use in New England is a large refrigerator car with doors at each end and an office at one end. It carries stacked 1,500 8½-qt. cans uniced or 1,300 iced. The new type car is a refrigerator car with the door in the middle and no office; it carries 308 40-qt. cans.

None of these three types of cars has ice bunkers; the milk is kept cool in summer by putting ice right on top of the cans. A car that is coming into use and is giving good satisfaction, both because of the excellent condition in which it keeps the milk and because of its economy, is the tank car. A glass-lined steel tank covered with asphalted cork brick that are wired on to the tank, is mounted in an ordinary refrigerator car. The tank is cylindrical with rounded ends and holds 12,486 qt. of milk or 1,469 cans. Milk shipped in these tank cars at 38° to 45°F. arrives in Boston at the end of a 175-mile trip with a temperature that is not

*Courtesy of J. O. Jordan.*

FIG. 37.—Ordinary type of car used for transporting milk in New England.

over 2°F. higher than the initial temperature; furthermore, at the low temperature that is maintained in transit there is no churning of the milk. The greatest difficulty in the use of these cars is to secure enough milk at the point of loading to fill the tank; to pick up milk at different points en route would result in materially raising the temperature and in the milk arriving at its destination in poor condition.

Mr. Zippel, General Agent of the Milk Department of the Delaware, Lackawanna and Western Railroad, in 1910 described the methods, which are practically unchanged at the present time, of transporting milk by rail. The standard car is 42 ft. over the end sills, with steel underframe, and, saving for high-speed air brakes, is from the floor down exactly like a first-class passenger coach. These cars have a capacity of 300 40-qt.

cans or 550 12-qt. boxes of bottled milk. The cars have end and side doors, beveled and cushioned with canvas, opening inward to facilitate handling at the platforms, and a large ice bunker in each corner. These bunkers are filled at the icing stations by removing the hatches which on the inside are beveled and cushioned with canvas.

A specially designed ventilating system insures uniform melting of the ice and thereby gives proper refrigeration. Insulation is provided by building the car with an outside sheathing of yellow poplar $\frac{3}{4}$ in. thick next which is an air space of $2\frac{1}{2}$ in. that is separated from a second air space of $1\frac{1}{2}$ in. by a sub-lining of white pine covered with Hydrex felt and sheathed inside with white pine.

*Courtesy of J. O. Jordan.*

FIG. 38.—New type of car used for transporting milk in New England.

Some railroads place the ice directly on the cans instead of using bunkers. Experiments were made at one time by one of the railroads to determine whether the color of the car influenced the temperature but it was found not to do so.

The milk cars of the Lackawanna are run on passenger trains, or as solid milk trains on passenger time. The trains are in charge of a milk messenger or train agent whose duties are similar to those of an express messenger and the service is of the character rendered by express companies except that the milk is called for by the consignees instead of being delivered by the company.

In making up milk trains, wherever carload shipments are made, a

car is supplied, which is cleaned, loaded and iced by the consignor, the rate on such shipments being 12½ per cent. less than that charged by L.C.L. shipments. The rest of the cars are distributed at convenient points along the line, the creameries at which they are left cleaning the car and loading the output, to which other consignments are added until the car is filled. Then the car is locked and carried to its destination where the milk is unloaded, the cars cleaned and the empty cans and boxes loaded for return to the shipping stations.

Milk is on the road 8 to 15 hr. according to the distance traveled. At the terminal in Hoboken there is a large force of cashiers, foremen and milk handlers to care for the business; the handling is all done at night, the cars arriving between 9:30 and 10:30 p.m. and returning between 3:30 and 3:50 a.m.

The Pennsylvania Railroad in 1914, daily hauled over 265,000 qt. of milk into Baltimore, Philadelphia, Jersey City and the Borough of Brooklyn. Prior to November, 1911, when the road established the office of milk agent, the company hauled no milk into Philadelphia from points north or west of Harrisburg, Pa., and no shipments of milk from any points on the railroad were made into New York and Brooklyn. Between these dates, an interval of 2½ years, with the coöperation of milk dealers of New York, Brooklyn and Philadelphia 53 shipping stations representing an investment of $450,000 were located in the dairy sections of northwestern Pennsylvania, New York and the Maryland-Delaware peninsula. To develop this long-haul traffic the railroad in 1912-13 built at the cost of $7,665 per car, 36 all-steel refrigerator cars which in the autumn of the latter year were put in service. These cars have two refrigerating compartments, each with a floor capacity of 160 46-qt. cans, 13 in. in diameter. The volume of the refrigerating compartment is 1,468 cu. ft. The brine tanks are two in number and have a radiating surface of 226 sq. ft. and a volume of 77.25 cu. ft. The screened portion above the tanks has a volume of 9.42 cu. ft. making a total capacity of 86.67 cu. ft., or a total volume capable of holding 3,814 lb. of crushed ice, weighing 44 lb. per cu. ft. The ratio of tank radiating surface to loading volume is 1 sq. ft. to 7.48 cu. ft., and the ratio of ice to milk is 2 lb. of ice to 8.6 lb. or 1 gallon of milk. The tanks have a 2-in. free air space around them and are 15 in. above the floor. They are separated from the storage rooms by a partition open at the top and bottom and screened, thus creating a circulation. All moisture from tanks is carried off from drip pan through drain pipes and traps. The tanks are connected by a 1¼-in. pipe, creating some circulation between them. This pipe also regulates the brine to a uniform height in both tanks, the height of pipe above the bottom of the tank being arranged so that a certain amount of brine remains. A riser connection to the pipe forms an overflow.

When refilling the tanks, the valve in the pipe connecting the tanks is opened and all water or brine above the horizontal pipe is drained off.

Before refilling the tanks with crushed ice and salt the valve is closed again, causing the warm water to rise to a height equal to the top of the pipe. Any surplus water runs off through the overflow pipe and outside the pipe without egress of air. The valve is manipulated by a rod and universal joints from the roof of the car by removing the plug door.

When the tanks are cleaned, the round plugs at the bottom are unscrewed about 1/4 in., when they release the brine; after it has drained off, the plug can be entirely unscrewed and the settlings removed.

In order that the car can be kept in a sanitary condition the floor is covered with galvanized sheet iron, all crevices being soldered, and after each trip or shipment of milk the floors are scrubbed.

With this type of car a temperature of 35° or 40°F. can be maintained.

The milk cars that the writer has inspected in Chicago have been very like ordinary baggage cars; in some of them a hinged shelf was attached to the side of the car to hold cans.

**Rates of Transporting Milk.**—The transportation of milk in New England was recently investigated by the Boston Chamber of Commerce. The great milk-producing territory was found to be Maine, New Hampshire, Vermont, Quebec and eastern New York, and the great consuming territory to be the 163 incorporated cities and towns of Massachusetts, Rhode Island and Connecticut, which together have a population between 5 and 6 millions. About 75 cars of milk move daily in New England and of these about 60 come to Boston. Milk is carried: (1) as express; (2) as excess baggage; (3) in leased cars; (4) under the Massachusetts Saunders law by which a per can rate is charged and the railroad unloads and ices the cars.

The shipping rates that prevail are very different; some railroads have a single rate, a passenger or a freight rate; others deduct 25 per cent. for all shipments by freight. Some rates are on a zone, while others are on a flat, per mile basis. Some railroads charge the same rate for milk and cream and others charge a higher rate for cream.

The Chamber finds it probable that cream and some milk will be shipped by express and advises that containers which may be insulated or covered to keep down the temperature be used. The shipping as excess baggage is usually unsatisfactory because of the high temperature in summer and the difficulty of grading but some cream and some local milk is shipped in this manner.

The leased car system by which the greater part of the milk and cream in New England is transported has tended to give the city milk dealers a monopoly of the business in the buying territory and in 75 per cent. of it this monopoly is already established; the farmer, finding it impossible to secure competitive bids, has had to accept the city milk dealers terms. The many short branch railroads along which but one car of milk is produced have helped create this system which tends to engender

strife betwixt the farmer and dealer and to make the farmer less ambitious to produce superior milk.

The Saunders law which was enacted in Massachusetts in 1910 compels the railroad to load, unload and ice milk and to furnish the same rate for one can as for 1,000 cans. The consequence has been that the large dealers forsook Massachusetts for other territory to the injury of the farmers of the State.

The Chamber advises the abolishment of the leased car system and the establishment of a uniform rate for milk and cream per can based on a zone or flat rate per mile, the railroads performing the loading, unloading, and icing. The rate for milk should be lower than that for cream. All deductions on account of freight train service should be abolished. The rate for a carload, when the shipper loads at not more than two stations in a given section and does his own icing and unloading, should be at a percentage less than the per can rate. Rates should be uniform throughout New England, thus enabling groups of farmers to ship to the market at an equal advantage with the dealers, or to secure competitive bids from the dealers. This system is substantially the same as that prevailing on the Pennsylvania, New York Central and Canadian Pacific Railroads. This suggestion of the Chamber has been virtually approved by the Interstate Commerce Commission which ruled against the leased car system.

It is advised that State and local boards of health prohibit the shipment of milk and cream at a temperature above a fixed maximum but that railroads should not be expected to reduce the temperature of milk and cream in transit. The establishment of country milk stations it is held will help to insure the shipment of milk at proper temperature.

In 1911, the Washington Chamber of Commerce investigated the milk situation in the District of Columbia and among other things attempted to secure information that would permit it to conclude as to the practicability of providing refrigerator car service, or alternative means, for maintaining milk in transit at below 50°F. Of the railways entering the District only the Pennsylvania and the Southern railways and the New York Central and Hudson River Railroad Co. heeded the requests of the Chamber for information.

The New York Central lines reported that the cost of refrigeration varies on different parts of the system, according to weather conditions, the kind of container in which the milk is shipped, the length of haul and the facilities for rapid handling at destination.

The Pennsylvania explained that three factors enter into the cost of hauling milk under refrigeration, to wit, the length of haul, the temperature of the milk when placed in the car, and the circumstance whether the cars are to be loaded at one point or at intervals between the originating point and destination. If the class "Rf" refrigerator car is to be used

for the purpose proposed, the initial icing was estimated to require 7,400 lb. After precooling 4,000 lb. of ice would suffice to maintain the milk at 50°F. for a distance of 300 miles or a 24-hr. run. However, if the car is to be opened at different points to receive milk the temperature will fluctuate in accordance with outside conditions. The cost of icing a car with 12,000 lb. of ice will approximate $15 on a basis of $2.50 a ton for ice and including necessary labor. By using the same cars in the milk service, the bunkers would retain a percentage of the ice from one trip to the next and thus the car would require on the same basis as above, an average of only about 3,000 lb. of ice at a cost of $4. Since the necesary space for loading, and the requisite amount of ice must be provided from the starting point of the car to the places of receiving and discharging its load, the length of haul does not materially affect the cost.

The railways transporting milk into Washington held that the length of haul and the total shipments were such that the necessary number of refrigerator cars could be furnished only at a rate which would make the retail price of milk prohibitively high.

At the time of the chamber's investigation the Pennsylvania lines carried milk into Washington from less than 30 miles at 1½ cts. per gallon; between 30 and 60 miles at 2 cts.; over 60 and not over 90 at 2½ cts. Double rates were charged for cream. The Southern Railway carried milk at a flat rate of 2½ cts. a gallon which included the return of empty receptacles.

**Improvement in Shipping Milk in Pittsburgh.**—In 1915 the Department of Public Health and the Chamber of Commerce of Pittsburgh with other civic bodies entered into negotiation with the railroads carrying milk into the city to persuade them to furnish refrigerator cars for the shipment of milk. The matter was finally referred to the Interstate Commerce Commission and ultimately with the aid of the Bureau of Chemistry the desired improvement was obtained. The situation was, that while part of the milk came from nearby dairies, part came from Ohio and was in transit 8 or 9 hr. The farmers were delivering a good article at the railroad stations but the temperature of the milk in baggage cars ran from 46° to 73°F., with most of it well above 65°. In many cases the temperature of the milk was much higher than it was at the way stations, the increase being sometimes as much as 15°F. The bacterial counts ran as high as 22,800,000 per cubic centimeter and the milk was known to "geyser" sometimes.

The railroads pointed out that with the milk delivered several times a day, in small lots, at many stations, they could not afford to supply refrigeration and had to handle the shipments as ordinary baggage. Consolidation of the shipments so that carload lots could be quickly taken aboard was essential if refrigeration was to be provided. The wholesalers agreed to furnish consolidated shipments so that the rail-

roads would have only one or two pickups and those were to be of important quantities and the farmers agreed to deliver milk at definite hours. It was recognized that the improved service made an increase in rates necessary and after some parleying an increase of 20 per cent. was agreed upon and approved by the Interstate Commerce Commission. When the tariff was adopted the Pennsylvania Railroad was ready to refrigerate 7,000 gal. a day; the Baltimore and Ohio promised to build cars to care for the milk between Painesville and Akron; the Lake Shore and Michigan Southern promised to operate cars between Andover, Ohio, Oil City, Pa., and intermediate stations, while the Erie and the Pennsylvania and Lake Erie Railroads agreed to care for the milk coming over their lines.

Branch lines connect the surrounding country with the collecting centers where the milk will be picked up for long haul to Pittsburgh. Both the railroads and milk dealers are building large ice houses in the dairy sections to store ice. Milk is now being received in Pittsburgh at temperatures not above 48°F. The smaller dealers can now have their milk stay in the refrigerator cars until time to deliver it in the city, whereas it was formerly necessary for them to meet the trains on their arrival in Pittsburgh between 10:00 p.m. and 2:00 a.m., and to remove the milk to the milk plants and refrigerate it. The refrigerator cars thus save rehandling the milk and are said to effect a reduction in the cost of refrigeration in Pittsburgh in excess of the added rates.

The transportation of milk by common carriers is a phase of the city milk question that is most important and seems likely to be a storm center in the near future. It is important to the dairy farmers that they shall have a railway service that shall get their milk to the cities in prime condition, and at reasonable rates. It is equally important that the railway service shall not build up a monopoly. The Boston Chamber of Commerce has pointed out the evil of the leased car system and it is held by others that the centralized creamery system depends for its existence on low rates for cream. The milk of many cities is carelessly handled and improperly refrigerated on its way to the city. The example of Pittsburgh where organizations of the citizens, the municipal and federal authorities coöperated in conference with the railroads shows how the problem must be met and augurs well for its solution.

**Temperatures and Age of Milk Handled by Contractors.**—In the spring of 1915 a committee of the International Milk Dealers' Association sent a questionnaire to the members of the association regarding the temperature and age of the milk they were handling, that information might be obtained which would be useful in improving milk supplies. It was particularly desired to elicit information as to conditions that prevailed during July and August. The 22 replies that were returned have been summarized in Table 67. The committee states that it is

TABLE 67.—TABLE PREPARED FROM DATA COLLECTED FROM 22 MEMBERS BY THE INTERNATIONAL MILK DEALERS ASSOCIATION RELATIVE TO THE TEMPERATURE IN °F. AT WHICH MILK IS HANDLED IN THE SEVERAL STAGES EN ROUTE FROM PRODUCER TO CUSTOMER

| | Replys | Massachusetts | New York | Pennsylvania | Maryland | Ohio | Indiana | Michigan | Wisconson | Minnesota | Iowa | Kentucky | Washington | California | P. Quebec | P. Ontario | P. Manitoba | Highest temp. reported for p. m. milk | Lowest temp. reported for p.m. milk | Av. temp. reported for p.m. milk | Highest temp. reported for a.m. milk | Lowest temp. reported for a.m. milk | Av. temp. reported for a.m. milk | Difference between av. temps. of p.m. and a.m. milk | Percentage of dealers whose milk had an av. temp. above 50°F. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Delivered by producers at country bottling plants | 2 | .. | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 60 | 45 | 53.0 | 80 | 50 | 65.0 | 12.0 | .... |
| Delivered by producers to country receiving stations | 14 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | .. | .. | .. | .. | 1 | .. | 1 | 80 | 45 | 61.4 | 90 | 40 | 66.8 | 5.4 | 100 |
| Delivered by producers to country railroad stations | 13 | 1 | .. | 3 | 1 | 1 | .. | .. | 1 | 1 | 1 | 1 | .. | 1 | .. | 1 | 1 | 80 | 40 | 53.8 | 80 | 45 | 59.3 | 5.5 | 83 |
| Delivered by producers to country milk plants | 15 | 1 | .. | 2 | 1 | 1 | .. | 1 | 1 | 1 | 1 | .. | 1 | 1 | 1 | 2 | 1 | 80 | 40 | 56.6 | 80 | 40 | 63.1 | 6.5 | 77 |
| Put by producers into railroad cars | 11 | 1 | .. | 1 | 1 | 1 | .. | 1 | 1 | 1 | .. | 1 | .. | .. | 1 | 1 | 1 | 80 | 40 | 56.4 | 80 | 40 | 60.5 | 4.1 | 89 |
| Put into railroad cars from country receiving stations | 13 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | .. | .. | .. | .. | .. | .. | 1 | 72(*a*) | 32(*a*) | 47.2(*a*) | .... | .... | .... | .... | 18 |
| Put into railroad cars from country bottling plants | 3 | .. | 2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 45(*a*) | 34(*a*) | 39.0(*a*) | .... | .... | .... | .... | 0 |
| When taken from railroad cars at city railroad stations | 15 | .. | 1 | 4 | 1 | 1 | 1 | 1 | 1 | .. | 1 | 1 | .. | .. | 1 | 1 | 1 | 80 | 36 | 55.6 | 85 | 42 | 59.8 | 4.2 | 69 |
| When taken from railroad cars at city milk plants | 3 | 1 | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. | 1 | .. | .. | 80(*a*) | 35(*a*) | 55.0(*a*) | .... | .... | .... | .... | .... |
| When received by dealers trucks at city railroad stations | 14 | .. | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | .. | .. | .. | 1 | 1 | 1 | 80 | 36 | 55.8 | 80 | 42 | 59.3 | 3.5 | 75 |
| When received by dealers trucks from country bottling plants | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | .. | .. | .. | .. | 40(*a*) | 40(*a*) | 40.0(*a*) | .... | .... | .... | .... | 0 |
| When received from dealers trucks from country milk receiving stations | 7 | 1 | .. | 1 | 1 | 1 | .. | .. | .. | 1 | .. | .. | .. | .. | 1 | .. | 1 | 80(*a*) | 35(*a*) | 53.5(*a*) | .... | .... | .... | .... | 50 |
| When received from dealers trucks at city milk plants | 14 | .. | 1 | 4 | 1 | 1 | 1 | .. | 1 | 1 | .. | .. | 1 | .. | 1 | 1 | 1 | 80 | 36 | 55.5 | 80 | 44 | 58.7 | 3.2 | 92 |
| When received by city delivery wagons from milk plants | 20 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 65(*a*) | 34(*a*) | 42.2(*a*) | .... | .... | .... | .... | 0 |
| When received by city delivery wagons direct from cars | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 80(*a*) | 60(*a*) | 70.0(*a*) | .... | .... | .... | .... | .... |
| When received by consumers from city delivery wagons | 18 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | .. | 1 | 2 | 1 | 90 | 38 | 50.2 | .... | .... | .... | .... | 28 |

(*a*) Both a.m. and p.m. milk.

aware that many of the figures are only estimates but that it feels that the replies as a whole very accurately express existing conditions.

Table 67 shows that milk is being transported and delivered at too high temperatures. Bacterial multiplication proceeds rapidly at temperatures above 50°F. and to prevent it, milk should be chilled well below that point. Yet, the average temperature of the milk that 77 to 100 per cent. of the dealers were accepting from their producers at receiving stations, railroad stations, milk plants and aboard train in the country, was above 50°F. The difference between the average temperature of the evening and morning milk delivered by the producers at these several places ranged from 4.1° to 6.5°F. and indicates that the morning milk is rushed off from the farm without the benefit of the thorough cooling the evening milk receives. The average temperature of the milk that 18 per cent. of these dealers were loading onto cars at country receiving stations was above 50°F. The three replies from country bottling plants indicate that the milk they put aboard train was thoroughly cooled which undoubtedly is widely true of these plants. The average temperature of the milk of 69 per cent. of the dealers, when taken from the cars at city railroad stations, of 75 per cent., when received by the trucks at the city railroad stations and of 92 per cent. when received from the trucks at city milk plants was above 50°F. The average temperature of the milk of no dealer was above 50°F. when loaded onto the delivery wagons but that of 28 per cent. of the dealers was above this temperature when delivered to customers.

**Use of Motor Vehicles in Collecting and Delivering Milk.**—Motor vehicles have been developed to a stage where they are useful for certain purposes in the dairy industry, namely, for the collection of milk and cream in the dairy districts and for its transportation to the country milk plants or to the railroad stations, and in the cities for hauling milk from railway terminals to the city milk plants and thence to their local distributing branches. They are also used in the cities to some extent for the delivery of milk, cream and condensed milk to hospitals, hotels, stores, confectionary establishments, ice-cream factories, bakeries and restaurants. They have been tried for regular house-to-house retail delivery but have usually failed in this field because of the continual stopping and starting, because two men are required for reasonable speedy delivery and because they cannot move unattended from door to door, as the ordinary intelligent horse does, while the driver is delivering bottles. However, where customers live at some distance from one another, as in suburban towns, or where a special milk such as a modified milk for babies is being delivered over an area of considerable size and with infrequent stops, even in retail delivery they have been successful.

Milk is shipped to the city, either bottled in cases or in cans. The bottled milk on arrival is ready for immediate delivery to the distributing

stations of the milk companies for house-to-house delivery by wagons, or for loading directly onto the delivery wagons. The milk that arrives in cans has to be carried to the milk plants, often for pasteurizing and always for recanning and bottling. Before the advent of the motor trucks the best location for the milk plants was near the terminals, because the milk often arrived at a rather high temperature and so needed prompt cooling, which it could not have if it was to be hauled a long distance by horses in heavily loaded wagons in which the icing of the cans was impracticable. The location of the plants at the terminals necessitates long hauls by the delivery wagons, and by the wagons that carry cases of bottled milk to the branch distributing stations. Bottled milk in cases weighs more and is more bulky than the same quantity of milk in cans; consequently it is true economy to plan so that the maximum part of the distance each gallon of milk is carried, shall be in cans. The speed of the auto truck makes it feasible to locate the city milk plant further from the railroad, in the heart of the retail section so that the delivery wagons which carry the bulk of the bottled milk shall have short trips and the branch delivery stations shall be conveniently accessible. There is some tendency to reconstruct the city milk business along these lines but heavy investments in plants at the terminals make readjustment slow. In city use, motor trucks have demonstrated their superiority to horse traction in the severe storms of winter, and in the torrid spells in summer when the horses suffer from the heat and traffic becomes slow and unreliable.

*The Commercial Vehicle* in 1914 investigated the use of auto trucks in the dairy business of Greater New York and found all of the 13 leading milk companies of the city using them; these concerns had 59 trucks in use. There were fifteen 10-ton, eight 6- and 6½-ton, three 4½-ton, six 4-ton, thirteen 3-ton, two 2-ton, six 1½-ton and six 1-ton vehicles. The popularity of the 10-ton truck is due to its economy. Motor truck efficiency depends on the principle that the larger the load the greater the efficiency provided this is consistent with good mileage and provided the tonnage can be carried the full distance. Some of the lighter trucks have proved unsuccessful, for the loading time is no less than with horses, so that in the limited running period, the truck has not long enough to show its efficiency. A four-horse team, making one trip per night, hauls more cheaply than a 5-ton truck making two trips. These 5-ton trucks have proved profitable in distributing to outlying delivery depots to which three trips a day may be made and considerable mileage covered. Trucks of more than 5 and less than 10 tons capacity were profitable because they admit of more rapid handling of the milk. Light trucks find their field in delivery to retail stores, in distributing condensed milk and in special deliveries. These light vehicles have expanded the radius of custom, accelerated the speed of delivery, cut down the number of

vehicles employed, thereby decreasing the loading time and congestion, and have decreased the cost of delivery.

In general, the mode of operation is to use the 10-ton trucks for transferring the bulk, and less often the cased milk from the trains to the main city milk plant, for carrying the cased milk from the main plant to the local delivery plants and for returning the empty utensils to the railway terminal. The medium-sized trucks are used less for the traffic between the terminals and the main plant, but more for that between the main plant and the local ones, and for delivery to hospitals, restaurants, confectionery establishments and stores that take good-sized orders of milk and that are considerable distance apart. The 1 to 2-ton trucks are used chiefly in special service.

The 10-ton trucks are of two sorts, regular motor trucks, and tractors that couple onto trailers, the latter having the advantage that on delivery of the load they can uncouple at once and couple up to other trailers, thereby saving time that the regular trucks lose in waiting to be unloaded and loaded again. The large trucks leave the garage early in the evening and go to the main and local plants for loads of utensils which they carry to the railway terminals and return therefrom with a load of milk, as a rule making two trips in a night which work is usually finished by six in the morning. In the day time these trucks are in service between the main and local plants.

The itinerary of a tractor and 10-ton trailer engaged in hauling milk from railway terminal to the main plant and of part of the itinerary of a 4-ton motor truck employed in distribution to stores appears in Tables 68 and 69.

There is marked difference in the efficiency with which the several trucks studied were operated and this is set forth in Table 70 which is self-explanatory. However, attention is called to the fact that the average commercial ton-miles made by the Howell-Demarset truck show that it was engaged in a different sort of traffic than the others. Table 71 shows the waste factor of standing time for the several trucks.

TABLE 68.—ITINERARY OF TRIPS WITH BORDEN'S CONDENSED MILK CO.'S KNOX-MARTIN TRACTOR, MAY 5–6, 1914[1]

[1] From *The Commercial Vehicle*, June 1, 1914.

Start made from garage at Gates and Ralph Avenues, Brooklyn, N. Y.
Vehicle —Knox-Martin tractor with a 10-ton trailer.
Load at start—tractor and fifth wheel only.
Crew at start—driver only.

Class of work—hauling raw milk from Jersey City terminals to Brooklyn pasteurizing plant.
Number of trips—two.
Route—from Brooklyn pasteurizing plant at 942 De Kalb Avenue to Erie freight terminal in Jersey City, N. J., via Williamsburgh Bridge and Chambers Street ferry.

DETAILED LOG OF TRIP

| No. of operation | Time, p.m. | Time of operation | Hours elapsed | Unit miles | Total miles | Load in pounds | Location of stop | Incident |
|---|---|---|---|---|---|---|---|---|
| Start | 6:58 | .... | .... | ... | ... | ..... | Gates and Ralph Avenues | Leave garage |
| 1 | 6:59 | 0:01 | 0:01 | ... | ... | ..... | ........ | Stop to light lamps. |
| 2 | 7:00 | 0:01 | 0:02 | ... | ... | ..... | ........ | Start. |
| 3 | 7:10 | 0:10 | 0:12 | 1.1 | 1.1 | ..... | 942 De Kalb Avenue | Arrive at pasteurizing plant, couple, with trailer loaded with 185 empty milk cans; change tail light and rear number; wait for helper to get ferry money. |
| 4 | 7:20 | 0:10 | 0:22 | ... | 1.1 | 5,080 | ........ | Leave. |
| 5 | 8:09 | 0:49 | 1:11 | 5.3 | 6.4 | ..... | Chambers Street ferry | Arrive at ferry gate. |
| 6 | 8:29 | 0:20 | 1:31 | ... | 6.4 | ..... | Jersey City slip | Leave ferry. |
| 7 | 8:33 | 0:04 | 1:35 | 0.3 | 6.7 | ..... | Erie terminal, Jersey City | Arrive, start to unload empty cans. |
| 8 | 8:46 | 0:13 | 1:48 | ... | 6.7 | ..... | ........ | Unloaded, maneuver to loading platform. |
| 9 | 8:55 | 0:09 | 1:57 | ... | 6.7 | ..... | Loading platform | Train not in, leave for supper. |
| 10 | 9:35 | 0:40 | 2:37 | ... | 6.7 | ..... | ........ | Return from supper, wait for train. |
| 11 | 9:39 | 0:04 | 2:41 | ... | 6.7 | ..... | ........ | Start loading. |
| 12 | 10:07 | 0:28 | 3:09 | ... | 6.7 | 19,980 | ........ | Loaded with 185 cans, start icing. |
| 13 | 10:10 | 0:03 | 3:12 | ... | 6.7 | ..... | ........ | Leave. |
| 14 | 10:11 | 0:01 | 3:13 | 0.3 | 7.0 | ..... | Chambers Street ferry | Arrive at ferry gate. |
| 15 | 10:28 | 0:17 | 3:30 | ... | 7.0 | ..... | New York slip | Leave ferry. |
| 16 | 11:22 | 0:54 | 4:24 | 5.2 | 12.2 | ..... | 942 De Kalb Avenue | Arrive pasteurizing plant, uncouple full trailer; couple on to trailer loaded with empties; change tail light and rear number. |
| 17 | 11:39 | 0:17 | 4:41 | ... | 12.2 | 5,080 | ........ | Leave. |
| | a.m. | | | | | | | |
| 18 | 12:20 | 0:41 | 5:22 | 5.0 | 17.2 | ..... | Chambers Street ferry | Arrive at ferry gate, missed 12:15 ferry. |
| 19 | 12:45 | 0:25 | 5:47 | ... | 17.2 | ..... | Jersey City slip | Leave ferry. |
| 20 | 12:46 | 0:01 | 5:48 | 0.3 | 17.5 | ..... | Erie terminal, Jersey City | Arrive, start to unload empty cans. |
| 21 | 1:00 | 0:14 | 6.02 | ... | 17.5 | ..... | ........ | Unloaded, maneuver to loading platform. |
| 22 | 1:09 | 0:09 | 6:12 | ... | 17.5 | ..... | Loading platform | Start loading 185 cans of milk. |
| 23 | 1:57 | 0:48 | 6:59 | ... | 17.5 | 19,980 | ........ | Loaded, leave. |
| 24 | 2:01 | 0:04 | 7:03 | 0.3 | 17.8 | ..... | Chambers Street ferry | Arrive at ferry gate, side-track for horses, last in. |
| 25 | 2:30 | 0:29 | 7:32 | ... | 17.8 | ..... | New York slip | Leave ferry. |
| 26 | 3:23 | 0:53 | 8:20 | 5.6 | 23.4 | ..... | 942 De Kalb Avenue | Arrive pasteurizing plant, uncouple trailer, change tail light and rear number. |
| 27 | 3:30 | 0:07 | 8:32 | ... | 23.4 | ..... | ........ | Run into street; breakfast. |
| 28 | 3:54 | 0:24 | 8:56 | ... | 23.4 | ..... | ........ | Leave. |
| 29 | 4:06 | 0:12 | 9:08 | 1.1 | 24.5 | ..... | Gates and Ralph Avenues | Arrive garage. |

RESUME OF ITINERARY STATISTICS

| | |
|---|---|
| Total time of two trips | 9 hr. 8 min. |
| Total miles traveled | 24½ |
| Total tonnage hauled | 25 tons |
| Total commercial ton-miles | 306.25 |
| Total time consumed in loading | 1 hr. 34 min. |
| Total time consumed in unloading | 43 min. |
| Total net time consumed in coupling and uncoupling four loads | 28 min. |
| Net running time | 4 hr. 8 min. |
| Net average speed | 3 miles per hour. |
| Net average running speed | 5.9 miles per hour. |
| Ratio of running time to total time | 45 per cent. |
| Average loading time | 38 min. |
| Average unloading time | 9.6 min. |
| Average time to couple or uncouple | 6.8 min. |
| Average of loading and coupling time | 22.4 min. |
| Average of unloading and uncoupling time | 10.2 min. |

TABLE 69.—ITINERARY WITH HOWELL-DEMARSET CO., THREE 4-TON PEERLESS TRUCKS, MAY 7, 1914[1]

[1] From *The Commercial Vehicle*, June 15, 1914.

| No. of operations | Time, a.m. | Time of operation | Hours elapsed | Unit miles | Total miles | Location of stops | Incident |
|---|---|---|---|---|---|---|---|
| 1 | 7:39 | 0:09 | 0:09 | ... | ... | Branch, Manhattan Street and Amsterdam Avenue.. | Arrive. |
| 2 | 7:58 | 0:19 | 0:28 | ... | ... | ........ | Wait to be unloaded. |
| 3 | 8:00 | 0:02 | 0:30 | ... | ... | ........ | Unload 14 empty cans; 23 empty cans left on truck |
| 4 | 8:10 | 0:10 | 0:40 | ... | ... | ........ | Load 494 qt. of milk in cans; 120 qt. in bottles.. |
| 5 | 8:16 | 0:06 | 0:46 | 1.4 | ... | Confectioner, 145th Street and 8th Avenue........ | Deliver 134 qt. of milk in 4 cans; load 4 empty cans. |
| 6 | 8:19 | 0:03 | 0:49 | ... | ... | ........ | Leave. |
| 7 | 8:28 | 0:09 | 0:58 | 1.7 | 3.1 | Confectioner, 116th Street and Amsterdam Avenue | Deliver 80 qt. milk and cream in 3 cans; load 11 empties |
| 8 | 8:34 | 0:06 | 1:04 | ... | 3.1 | ........ | Leave. |
| 9 | 8:35 | 0:01 | 1:05 | 0.1 | 3.2 | Druggist, 114th Street and Amsterdam Avenue.... | Deliver 20 qt. milk in bottles. |
| 10 | 8:37 | 0:02 | 1:07 | ... | 3.2 | ........ | Leave. |
| 11 | 8:39 | 0:02 | 1:09 | 0.4 | 3.6 | Druggist, 111th Street and Broadway............ | Deliver 40 qt. in 2 cans; load 3 empty cans. |
| 12 | 8:44 | 0:05 | 1:14 | ... | 3.6 | ........ | Leave. |
| 13 | 8:46 | 0:02 | 1:16 | 0.4 | 4.0 | Confectioner, 106th Street and Amsterdam Avenue.. | Deliver 69 qt. milk and cream in 3 cans; load 3 empty cans. |
| 14 | 8:49 | 0:03 | 1:19 | ... | 4.0 | ........ | Leave. |
| 15 | 8:51 | 0:02 | 1:21 | 0.4 | 4.4 | Druggist, 101st Street and Broadway........... | Deliver 67 qt. milk and cream in 3 cans; load 3 empty cans. |
| 16 | 8:55 | 0:04 | 1:25 | ... | 4.4 | ........ | Leave. |
| 17 | 8:57 | 0:02 | 1:27 | 0.3 | 4.7 | Druggist, 96th Street and Broadway.............. | Deliver 44 qt. milk and cream in 3 cans; load 3 empty cans. |
| 18 | 9:02 | 0:05 | 1:32 | ... | 4.7 | ........ | Leave. |
| 19 | 9:04 | 0:02 | 1:34 | 0.3 | 5.0 | Confectioner, 96th Street and Columbus Avenue.. | Deliver 10 qt. milk and cream in 3 cans; load 3 empty cans. |
| 20 | 9:06 | 0:02 | 1:36 | ... | 5.0 | ........ | Leave. |
| 21 | 9:19 | 0:13 | 1:49 | 2.0 | 7.0 | Lunch room, 57th Street and Broadway........... | Collecting bill. |
| 22 | 9:30 | 0:11 | 2:00 | ... | 7.0 | ........ | Leave. |
| 23 | 9:31 | 0:01 | 2:01 | 0.1 | 7.1 | Battery repair shop, 55th Street and 8th Avenue... | Leave spark plug battery to be recharged. |
| 24 | 9:32 | 0:01 | 2:02 | ... | 7.1 | ........ | Leave. |
| 25 | 9:42 | 0:10 | 2:12 | 1.4 | 8.5 | N. Y. Central Railroad terminal, 34th Street and 10th Avenue........ | Unload 56 empty cans. |
| 26 | 9:47 | 0:05 | 2:17 | ... | 8.5 | ........ | Leave. |
| 27 | 9:57 | 0:10 | 2:27 | 1.8 | 10.3 | No. 1 Jefferson Market, branch market.......... | Arrive. |
| 28 | 10:10 | 0:13 | 2:40 | ... | 1.03 | ........ | Load 45 empty cans, 8 cases full quart bottles, 3 cases full pints and 35 cases empty bottles. |
| 29 | 11:06 | 0:56 | 3:36 | ... | 10.3 | ........ | Lunch. |
| 30 | 11:19 | 0:13 | 3:49 | 1.8 | 12.1 | New York side, Chambers Street ferry........... | Arrive at feerry gate. |
| 31 | 11:24 | 0:05 | 3:54 | ... | 12.1 | ........ | Wait for ferry boat. |
| 32 | 11:36 | 0:12 | 4:06 | ... | 12.1 | ........ | Leave ferry boat. |
| 33 | 11:41 | 0:05 | 4:11 | 0.3 | 12.4 | Main plant, 144 Provost Street, Jersey City, N. J... | Arrive. |
| 34 | 11:56 | 0:15 | 4:26 | ... | 12.4 | ........ | Unload all material. |
| 35 | 12:00 | 0:04 | 4:30 | ... | .... | Garage, 142 Provost Street, Jersey City, N. J....... | Enter garage. |

TABLE 70.—COMPARISON OF THE OPERATION OF AUTO TRUCKS (*The Commercial Vehicle*, 1914)

| | Average commercial ton-miles per trip | Average speed, miles per hour | Net average speed, miles per hour | Ton-miles per hour | Ratio of combined loading and the loading time to total standing time | Per cent. running time | Per cent. standing time |
|---|---|---|---|---|---|---|---|
| Borden's Knox-Martin tractor with 10-ton trailer | 152.8 | 2.7 | 5.9 | 33.5 | 45 | 45 | 55 |
| Empire State Dairy Co's. 5-ton Garford tractor with 10-ton trailer. | 145.5 | 2.4 | 8.3 | 29.2 | 52 | 35 | 65 |
| Slawson-Decker's 10-ton Hewitt truck | 126.2 | 1.9 | 5.6 | 29.3 | 78 | 33 | 67 |
| Empire State's 5-ton Garford truck | 171.6 | 5.7 | 10.5 | 45.0 | 76 | 57 | 43 |
| Howell-Demarset's 4-ton Peerless truck | 27.0 | 3.3 | 9.9 | 57.7 | 50 | 33 | 67 |

TABLE 71.—WASTE FACTOR OF STANDING TIME FOR SEVERAL DAIRY TRUCKS (*The Commercial Vehicle*, 1914)

| | Per cent., loading time | Per cent., unloading time | Per cent., waste time |
|---|---|---|---|
| Borden's tractor with 10-ton trailer | 31 | 14 | 55 |
| Empire State Dairy Co.'s tractor with 10-ton trailer | 34 | 18 | 48 |
| Slawson-Decker's 10-ton truck | 34 | 44 | 22 |
| Empire State's 5-ton truck | 33 | 43 | 24 |
| Howell-Demarset's 4-ton truck | 26 | 24 | 50 |

In a small way the motor cycle has been utilized for carrying milk and cream and it is possible that in the future it may be of considerable help to small dairymen.

The cost of operation of motor vehicles in dairy traction, is of course, very variable; the items that make it up may be gleaned from Pender and Thompson's estimate of the costs of operating a 3½-ton draft beer delivery truck and from Thompson's estimates on two 10,000-lb. brewery trucks (Tables 72 and 73).

TABLE 72.—ESTIMATES OF COST OF OPERATING A 3.5-TON DRAFT BEER DELIVERY TRUCK (PENDER AND THOMPSON)

| | | | |
|---|---|---|---|
| Average maximum load in pounds, approximately | ..... | ..... | 7000.0 |
| Miles per trip | ..... | ..... | 14.0 |
| Calls per mile | ..... | ..... | 0.7 |
| Hours per trip for loading and unloading | ..... | ..... | 8.0 |
| Hours working per day | ..... | ..... | 9.0 |
| | 7,900-lb. electric | 7,000-lb. gasolene | Two-horse wagon (two extra horses) |
| Average running speed in m.p.h. | 7.0 | 8.5 | 4.0 |
| Hours per trip standing | 2.1 | 2.1 | 2.1 |
| Hours per trip moving | 2.0 | 1.7 | 3.5 |
| Hours per trip total | 4.1 | 3.8 | 5.6 |
| Average number of trips per 9-hr. day | 2.2 | 2.4 | 1.6 |
| Miles per day | 31.0 | 33.0 | 22.0 |
| Calls per day | 22.0 | 23.0 | 15.0 |
| Days used per year | 285.0 | 270.0 | 285.0 |
| Vehicle-miles per year | 8,850.0 | 8,900.0 | 6,250.0 |
| Calls per year | 6,200.0 | 6,230.0 | 4,370.0 |
| Expense per year: | | | |
| Tires or shoeing | $330.00 | $380.00 | $144.00 |
| Repairs | 300.00 | 625.00 | 125.00 |
| Battery | 360.00 | ..... | ..... |
| Veterinary | ..... | ..... | 24.00 |
| Lubricants | 15.00 | 60.00 | ..... |
| Electricity at 3 cts. per kw.-hr. | 265.00 | ..... | ..... |
| Gasolene at 16 cts. per gal. | ..... | 350.00 | ..... |
| Feed | ..... | ..... | 760.00 |
| Garage or stable | 240.00 | 240.00 | 280.00 |
| Driver and helper | 1,210.00 | 1,280.00 | 1,210.00 |
| Depreciation | 290.00 | 610.00 | 250.00 |
| Interest | 102.00 | 120.00 | 38.00 |
| Insurance | 140.00 | 180.00 | 35.00 |
| Total annual expense | 3,252.00 | 3,854.00 | 2,866.00 |
| Cost per day | $11.40 | $14.25 | $10.00 |
| Cost per mile | 0.39 | 0.43 | 0.46 |
| Cost per call | 0.52 | 0.62 | 0.66 |

TABLE 73.—DATA ON GASOLENE-VEHICLE OPERATION (THOMPSON)
(5-ton wholesale delivery trucks)

| | | |
|---|---|---|
| General Information: | | |
| Business | Brewery | Brewery |
| Class of service | Heavy trade | Wholesale delivery |
| Rating of trucks, pounds | 10,000 | 10,000 |
| Number of trucks | 1 | 1 |
| First cost, dollars per truck | 4,800 | 5,100 |
| Age of truck at time of report, months | 10 | 12 |
| Months covered by report | 10 | 12 |
| Kind of tires | Solid | Solid |
| Nature of roads | Good | Excellent |
| Nature of grades | Flat | Rolling |
| Performance: | | |
| Miles per annum | 8,870 | 11,700 |
| Days used per annum | 292 | 294 |
| Miles per day used | 30 | 40 |
| Pounds hauled per day | 6,500 | ..... |
| Miles covered per gallon of gasolene | 4.13 | 4.65 |
| Operation and maintenance: | | |
| Gasolene, cents per gallon | 9.5 | 14.0(*a*) |
| Lubricants, dollars per annum | 33 | 118 |
| Tire renewals, dollars per annum | 541 | 941 |
| Repairs, dollars per annum | 244 | 410 |
| Painting, dollars per annum | 77 | ..... |
| Lubricants, cents per mile | 0.4 | 1.0 |
| Gasolene, cents per mile | 2.3 | 3.0 |
| Tire renewals, cents per mile | 6.1 | 8.0 |
| Repairs and painting | 2.7 | 3.5 |
| Garage rent, garage labor and general expense | ..... | 180 |
| Driver | 938 | 1,090 |
| Helper | 726 | 960 |
| Overhead charges: | | |
| Amortization, dollars per annum | 284 | 548 |
| Interest | 291 | 153 |
| Fire and liability insurance | 102 | 231 |

(*a*) Average price for the period approximate.

**Age of Milk When Delivered to Consumers.**—The time that elapses between the milking of the cows and the delivery of the milk to the consumer is a matter of importance. It varies greatly in the different cities for some like Baltimore, Chicago and Milwaukee fortunately draw their milk supplies from producing regions but a few hours distant, whereas Boston gets much of its supply from Canada, Maine and Vermont while milk comes into New York City from points 400 miles distant. Table 74 summarizes information supplied by 22 dealers of the International Milk Dealer's Association in regard to milk in transit to them in three Provinces and 13 States. Some of the interesting points brought out are, that on the average the morning milk handled by these dealers re-

mained in the farmers possession $2\frac{1}{2}$ hr., the night 12 hr.; that the milk was held in the country receiving stations and bottling plants $5\frac{1}{2}$ to $6\frac{1}{2}$ hr.; that it was $4\frac{1}{4}$ hr. on the cars en route to the city; that it was held in the city milk plants $16\frac{1}{4}$ hr.; and that the morning's milk was 31 and the night's 40 hr. old when delivered to the consumers.

Table 74.—Number of Hours Milk is Held in Stages of its Journey from Farm to Consumer. Prepared from Report of the International Milk Dealers' Association

| | Number of dealers replying | Average maximum number of hours reported by all dealers | Maximum number of hours reported by any one dealer | Minimum number of hours reported by any one dealer | Average minimum number of hours reported by all dealers | Average number of hours reported by all dealers |
|---|---|---|---|---|---|---|
| In farmer's possession after milking: | | | | | | |
| Night milk | 22 | 36 | 15.1 | 1/5 | 9.2 | 12.1 |
| Morning milk | 20 | 24 | 5.6 | 1/4 | 1.0 | 2.5 |
| Remaining at country receiving stations | 11 | 24 | 11.6 | 1 1/12 | 2.2 | 5.5 |
| Remaining at country bottling plants: | | | | | | |
| Night | 1 | 3 | ...... | 3 | ...... | 3.0 |
| Morning | 2 | 12 | 8.6 | 1 | 4.6 | 6.6 |
| Remaining at country railroad stations from delivery by farmers till loaded on cars | 11 | 2 | 1.7 | 0 | 0.3 | 0.7 |
| Remaining in railroad cars | 19 | 24 | 7.2 | 1/2 | 1.9 | 4.3 |
| Hours elapsing between removal from cars and arrival at city milk plant | 19 | 4 | 1.4 | 1/4 | 0.5 | 1.0 |
| Hours between arrival at city milk plant and loading onto city delivery wagons | 21 | 48 | 22.5 | 0 | 10.1 | 16.3 |
| Hours on city delivery wagons | 21 | 14 | 8.2 | 1 1/2 | 1.9 | 4.6 |
| Total age of milk when delivered to consumers: | | | | | | |
| Night | 16 | 84 | 53.2 | 2 1/4 | 28.4 | 40.3 |
| Morning | 17 | 84 | 41.9 | 2 1/4 | 18.7 | 31.2 |

**Cost of Operating Delivery Wagons.**—The cost of operation of delivery wagons varies greatly in different localities. The data collected by Thompson as given in Table 75 show how this cost is reckoned.

Table 75.—Data on Horse-vehicle Operation (Thompson)[1]

| | | | |
|---|---|---|---|
| General Information: | | | |
| Business | Milk | Milk | Milk |
| Number of one-horse wagons | 1,234 | 62 | 11 |
| Number of two-horse wagons | 237 | 8 | 1 |
| Average number of horses | 1,983 | 86 | 14 |
| Percentage of extra horses | 16 | 10 | 8 |
| First cost of one-horse wagon, dollars | 225 | 275 | 235 |
| First cost of two-horse wagon, dollars | 225 | 500 | 235 |
| Average price paid for horses | 225 | 250 | 225 |
| First cost per set of harness | 25 | 45 | 50 |
| Performance: | | | |
| Miles traveled per day | 8 | 20 | 12 |
| Trips per wagon per day | 1 | 1 | 1 |
| Deliveries per wagon per day | 225 | 150 | 250 |
| Pounds hauled per wagon per day | 2,000 | 1,800 | 2,000 |
| Operation and maintenance: | | | |
| Shoeing dollars per annum, per horse | 21 | 20 | 24 |
| Veterinary dollars per annum, per horse | 3 | 3 | 3 |
| Feed | 180 | 168 | 180 |
| Stable rent, stable labor and general expense, dollars per annum, per horse | 50 | 82 | 82 |
| Wagon repairs and painting, per wagon | 100 | 86 | 28 |
| Harness repairs, per wagon | 5 | 12 | 1 |
| Driver, per wagon | 780 | 776 | 780 |
| Overhead charges: | | | |
| Interest and amortization, dollars per annum, per horse | 34 | 25 | 14 |
| Interest and amortization, single wagon, dollars per annum, per wagon | 38 | 48 | 17 |
| Interest and amortization double wagon, dollars per annum, per wagon. | 38 | 82 | 17 |
| Total per annum dollars: | | | |
| Operation per horse | 254 | 273 | 289 |
| Maintenance per wagon | 105 | 98 | 29 |

[1] From "Relative Fields of Horse, Electric and Gasolene Trucks," *Res. Bull.* 4, Dept. Elect. Eng., Mass. Inst. Tech., 1914.

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## CHAPTER VI

## THE MILK CONTRACTOR

**Advent of the City Milk Problem.**—Dairying is one of the oldest arts of the human race. It is not known when man began to keep milk-giving animals but records show that dairying was practised in India 1,500 years and in Egypt 2,000 years before Christ. Like the origin of dairying itself, that of the problem of public milk supply is lost in antiquity. It is conceivable that as long as man led a nomadic life the art did not exist but it must have appeared soon after he established fixed abodes and have become pressingly important wherever he built large cities. The complexity of the question has increased apace with advancing civilization till in modern times its solution severely tests man's highest abilities and involves large amounts of capital. In the United States the transition from rural to urban communities was rapid, consequently the problem of city milk supply suddenly loomed large so that Americans are apt to think it new, whereas it is very old.

Though the change has come quietly, it has been a matter of years and though our oldest cities have been struggling with the problem since the middle of the last century and even earlier, in its modern aspect it has forced itself to the front only within the last 25 years, so that it belongs peculiarly to the present generation. It is easy to trace its development.

In small country towns most families have their own cows; those that do not depend on a neighbor for their milk supply, as a rule calling at the farm for their milk. There is no milkman and the amount of milk that can be purchased is very limited. Indeed summer visitors and others, in such places, often experience considerable difficulty in getting milk at all. As these villages grow, the demand for milk becomes large enough to encourage some farmer to embark in the milk business. As trade increases, he finds that he cannot raise enough milk and buys of other farmers. Thus in embryo the milk contractor appears, and some of the evils of contracting begin, for the milkman rarely has any control over the farmer and the latter seldom gets enough for his milk to encourage him either to improve the conditions under which it is produced or to take special care of it. Such as it is, it is accepted as the best obtainable by the milkman, but it is very apt to be disposed of to the customers who take little milk and to those who are poor pay. The growth of the village into a town or small city increases the demand for milk and the success of the one milkman tempts others to start in the business. It may be

overdone, which invites sharp practice such as watering and skimming of the milk, and there very likely follows a period of uncertain development. Routes change owners in quick succession; it is a time of in-and-outers, for farmers peddle milk when prices are good and quit to carry their milk to a creamery when they are bad. At this stage the milk-consuming public suffers; it is a period of poor milk and unreliable service. Nevertheless a few milkmen succeed in establishing a reputation and in convincing people that they have the intelligence and capital to succeed. They absorb the trade of the weaker dealers and carry on the bulk of the business, supplying the city with milk from their own farms and those of their neighbors in the city and its environs. Gradually the farms within the corporate limits of the city give way to city blocks and land in the suburbs becomes so high-priced that it cannot be profitably farmed, so that the milk supply comes from further and further away, till at last it is no longer within wagon haul, and the intimate relationship that existed in the village between the dairy farmer and the consumer is lost. By whom the milk is produced and whence it comes, the city man does not know. His milkman is one who buys the milk at wholesale from the dairyman and retails it to the consumer. This newcomer is known as the middleman, city milkman, or contractor.

**The Milk Contractor.**—His advent comes about naturally and for several reasons. Dairy farming is a business in itself and requires all the time, thought and energy the man who carries it on has. Likewise the selling of milk is a business complete in itself and the creation and maintenance of an organization competent to render the prompt and reliable service necessary for the city man to deal understandingly with him and to collect payment for service rendered, can hardly be well done by one absorbed in the problems of production. Also, the handling of the milk on its arrival in the city, preparatory to delivery, requires knowledge and training not possessed by the farmer. Finally, the separation of the city milk trade from that of milk production effects a division of capital so that the burden of financing the business falls less heavily on both producers and retailers, and in the country makes it possible for men to engage in dairying who could not do so if they had to pay for the shipment of milk to the city and in any large measure be responsible for it there. In fact in the early days before the city milk business became stable, severe losses were suffered by dairymen who not rarely sold milk to men who had not sufficient capital and so failed, leaving the farmer in the lurch with a large amount of money due him and no market for his milk till he could find a new contractor to handle it.

The contractor, then, is the middleman who in building his own business has made himself all but indispensable to both the milk consumer and milk producer. To the consumer, the contractor must deliver clean wholesome milk in order to win his trade and hold it. The city man is

usually ignorant of the methods that are in use to protect the milk supply and of the value of milk as a food. So it is good policy for the dealer to become his mentor and interest him in both. It is common for dealers to take this attitude and deliver illustrated lectures before church societies and women's clubs, explaining the dairy business from the farm to the consumers' door. Advertising literature is distributed, telling the merits of the several brands of milk handled by the dealer, setting forth the food value of milk and telling how to care for it. Often clubs of various sort are entertained at the city milk plant, which they inspect and afterward listen to a talk on milk and are served a luncheon of dairy products dealt in by their hosts. Occasionally trips may be conducted to the farms. By such methods suspicion is laid and in its place hearty confidence in dairying and dairy products established. Such work is expensive but necessary. It is an element in the cost of carrying on the milk business that the dairy farmer rarely thinks of but one from which he reaps profit for it stimulates the use of milk.

The relations between the farmer and the city milkman is delicate. Neither can thrive at the expense of the other and yet the one is interested in getting the best possible price for his milk, and the other in purchasing it at the lowest figure. If conditions are such that the contractor can and does squeeze the farmer, the latter will produce a low-grade milk and in addition be disgruntled and antagonistic to the contractor and finally, if he becomes convinced that there is no money in dairying, will sell his cows and take up other lines of farming. On the other hand, if the dairy farmers by combination and agreement are able to withhold milk from the market long enough to wring high prices from the contractor his profits are materially lessened, for he is generally loth to raise prices to the consumer because there usually results a great outcry against his supposed greed and there is also likely to be a decreased consumption of milk for the wages of city folk are for the most part fixed and they are both unable and unwilling to pay more for milk. Moreover, a principal reason that milk is so widely used is that it offers good food value cheap and raising its price brings it into competition with other foods and consequently encourages people to use them. The price of milk is fixed primarily on the ability and willingness of the city man to pay for it. Out of his demand grows the competition for the farmer's milk.

**Different Branches of Dairying Dominate Producing Territory.**—Milk is wanted for dairy manufactures and for city milk; the products of the former are butter, cheese, condensed milk, milk powder and ice cream and as the latter it is consumed in its natural state and as specially prepared beverages. It follows that there is competition for dairy territory between cheese factories, creameries, condenseries and city milk plants. Usually cheese makers pay least for milk so that the cheese industry is, broadly speaking, built up in new dairy territory, or that which is located too far

from a large city to supply the city milk trade, or where railroad facilities are undeveloped, or transportation rates unfavorable for creameries and condenseries. Creameries pay more for milk than cheese factories but usually less than condenseries, so that it is often possible for the latter to convert creamery territory to their use. City milk dealers pay most for milk and the growth of cities compels them to reach out further and further for it, consequently they capture dairy districts that formerly supplied the dairy manufacturers. Each business has its peculiar needs and dairying takes on character in accordance with them, the purchaser in each case being the power that shapes the development of the territory.

**Influence of Contractors in Dairy Districts.**—The influence of dealers who buy milk from a few farms is small, even though the entire dairy business of the country round consists in supplying such men. So also, is that of a class of wholesalers who supply an inferior grade of milk to cities having weak or badly enforced milk ordinances, for these men succeed by picking up any and all sorts of milk at the lowest prices and bother little about the development of the country so long as it produces the milk they need. Dealers who are in the business in a larger way have it within their power to lead the communities in which they operate into the paths of sound dairying and some of them do so, but most fail to keep in intimate contact with their producers and are surprisingly indifferent and ignorant as to conditions in the dairy country on which they are dependent. These men are satisfied to rely on the inspections of boards of health to maintain proper sanitary conditions, and do not perceive the advantages of supplementing such inspection, by the efforts of men in their own employ who will keep them accurately informed as to the conditions under which the milk they are buying and for the quality of which they are responsible is produced, who also, will have an educative influence, and who may be expected to establish cordial relations between dealers and producers. The large dairy companies are doing the best work for the producers. They have inspectors who instruct the dairymen in animal breeding and in the feeding and management of herds and who earnestly endeavor to establish good feeling between the farmer and the companies by helping each to an understanding of the others difficulties. These inspectors employed by the companies are in a position to win the confidence of the dairyman and so they have considerable influence which on the whole has been used in a way to materially advance the dairy industry. Many companies issue helpful reading matter to their patrons, and occasionally one of them, for the instruction of its dairymen, organizes an enormously expensive campaign, such as that of the Supplees against tuberculosis.

**Basis on which Milk is Purchased.**—The basis on which dealers and producers do business naturally varies; there may or may not be a contract between the two. Where the dealer holds the whip hand he merely

agrees to take the milk the dairyman brings him, paying therefor what and when he chooses, or a few weeks in advance, he may set the price of milk for the ensuing month. In better-developed dairy districts sounder business relations exist; written contracts are made for 6- or 12-month periods. These contracts vary a great deal; they commonly state the price to be paid each month for milk and often contain a clause to the effect that the daily deliveries of milk by the dairyman shall not vary more than a stated percentage above or below the amount called for in the contract. Other clauses are often inserted whereby the dairyman agrees to do certain things such as to exclude certain breeds of cows from his herd, to have his herd tuberculin-tested every 6 months, not to use divers kinds of feed, to build a milk house or silos, or to cool his milk right after milking and to deliver it at the receiving station between certain hours and below a fixed temperature. In these long-term contracts the price paid for milk varies from month to month, usually being lower in June and the early summer months than in mid-winter.

The basis on which milk is bought varies; the U. S. Department of Agriculture states that the following systems of purchase are in common use:

1. By the quart or gallon.

2. By the can, the size of which varies from 8½ to 40 qt. or more.

3. By the can, with the stipulation that the can of milk must come up to the standard weight.

4. By the can or gallon, with a minimum standard for butterfat and a definite premium per gallon for each 0.1 per cent. butterfat above a certain fat test as, for instance, 3.8 per cent.

5. By the gallon, the number of gallons being determined by dividing the weight of the milk by 8.6.

6. By weight by assuming a fixed weight for a can of milk and multiplying it by the number of cans.

7. By weight, the milk being actually weighed.

8. By weight, as by No. 4, with in addition a stated minimum standard for dairy farm score with a premium for points scored above the standard.

9. At a certain rate per pound for butterfat plus so much per 100 lb. for skim-milk; *e.g.*, at 38 cts. a pound for butterfat and 70 cts. per 100 lb. for skim-milk, 100 lb. of milk would bring $3.3 \times 0.38 = 1.25 + (96.7 \times 70 = 68) = \$1.93$.

10. On the same basis as No. 9, except that the weight of whole milk instead of skim is considered.

11. By weight, with additions or deductions to the rate according as the percentage of butterfat rises or falls above or below an established standard. Premiums may be paid for each 0.1 per cent. of butterfat above the standard, and deductions made from each 0.1 per cent. below it or sometimes premium is paid only for milk 0.3 per cent. above the standard while deductions are made for each 0.1 per cent. below it.

12. Milk is bought on a base rate which is established for each month in the year by averaging the butterfat content of the milk for each month over a series of years and fixing the rate in accordance therewith, a premium of 3 cts. per 100 lb. in summer and 4 cts. per 100 lb. in winter being paid for each 0.1 per cent. of butterfat that the milk runs in excess of the average and a like deduction being made for each 0.1 per

cent. that the milk falls below it. A deduction is also made if the solids-not-fat are less than 8.5 per cent. Milk of less than 2.5 per cent. butterfat content is paid for on a sweet-cream-fat basis.

13. A certain price is paid per per cent. of butterfat per gallon.

14. Milk is graded and paid for at 3 to 4 cts. per 0.1 per cent. of butterfat per 100 lb. for grade B milk. Grades are determined by: (1) bacterial content of the milk; (2) sediment test; (3) acidity; (4) flavor and odor; and (5) temperature on arrival in the city. For grade A milk, a premium of 5 cts. per 100 lb. is added; for grade C milk, a reduction of 5 cts. per 100 lb. is made from grade B prices. Should a producer furnish grade C milk for 2 successive months the dealer may cancel the contract.

15. Extra prices are paid farmers for special milks such as that which is tuberculin-tested.

Methods of purchase which do not take into account the percentage of butterfat in the milk encourage farmers to keep high-producing cows that give milk of low butterfat content. In general, it is poor policy not to pay on the quality basis. Clean milk and rich milk costs more to produce than thin milk or dirty milk; therefore, a method of payment should be adopted that will adequately reward the producer of superior milk. No single system can be recommended for universal use, because the character of the trade varies and should decide the method of purchasing. Premium for barn scores, for bacterial counts, etc., and the grading of milk are most likely to prevail in dairy districts supplying a well-regulated city milk trade. Probably, it would be good for the dairy business if all milk were purchased by the 100 lb., for the dealers would then weigh the milk they buy, and so would pay only for that they actually receive; which would cut down their losses from short measure resulting from battered cans, etc.

The dairy division of the Bureau of Animal Industry found that of 87 plants in four Eastern cities, six bought all the milk by weight, 21 part by weight and part by measure and 60 entirely by measure. However, as it was the larger dealers who in most cases bought by weight the amount of milk bought on this basis was greater than the figures indicate. Tests at one of the plants that was buying by measure of 55 10-gal. cans showed that the net weight of milk varied from 80 to 86¾ lb.; the average being 83¼ lb. or 2¾ lb. less than the accepted weight of 10 gal. of milk. The average net weight of milk in this dealer's quart bottles was 2.115 lb. which means that he was getting but 39.36 qt. of milk on an average from his 40-qt. cans or he was running a loss of 1.6 per cent. per can. Loss also occurs from the fact that much of the milk that is bought by measure is afterward cooled and contracts in volume in the process. Experiments show that in cooling milk from 70° to 50°F. the shrinkage is at least 0.2 per cent. Moreover if milk were sold by the pound dairymen would think in terms of weight instead of bulk, which would tend to encourage them to weigh the milk each cow produced. Or stated briefly, the use of the pound as the unit of bargaining tends toward exactness and elimination of waste.

Sweet cream is bought on the butterfat or butterfat and skim-milk basis.

**Tendency to Concentration.**—Milk producers and milk consumers shrewdly discuss whether the milk contractors are so organized locally and nationally as to constitute a monopoly. It is claimed that a few big dealers have so manipulated things that they can dictate to the farmer the price at which he shall sell milk, and to the consumer what he shall pay for it. It is intimated that the contractor's profits are inordinate and that his high prices to consumers have curtailed the consumption of milk and his low prices to the farmers have caused them to produce less and, therefore, more expensively.

Some producers hold that the schedules of prices put out from time to time by the big dealers are so similar that they indicate collusion in fixing the price of milk, and that unfair methods of competition are resorted to such as, at loss, underselling the small dealer in the city and outbidding him in the country till his business is ruined and he is compelled to quit. This belief that coercive policies are used has in a manner been strengthened by the Boston Chamber of Commerce's arraignment of the leased car system and its subsequent discontinuance by the Interstate Commerce Commission. Certain leaders of the producers believe that the only way the dairy farmer can secure fair prices is to cease dealing as individuals with the contractors and sell his milk through various sorts of farmer's unions. The growth of this feeling has led milk producers to precipitate great milk strikes in Chicago, St. Louis, Boston and New York that have attracted national attention both among dairy farmers and consumers. It has led J. J. Dillon, State Commissioner of Foods and Markets of New York State, to propose that a plan in use in Denmark be followed. He advises that in every dairy section of the State the producers should form a local association and legally appoint it the agent for the sale of their milk, thereby putting all the milk of a district into a single agency for sale and making it impossible for the members to sell their milk personally. The local organizations would be federated in a single agency for the sale and distribution of milk. Acting on this idea the Dairyman's League of New York State has notified its members that it is in a position to market their milk under existing contracts with producers and has designated the New York State Department of Foods and Markets as the exclusive agent for the sale of milk. Thus the members of the association delegate their authority to sell their milk to the association of which they are members and the association concentrates this authority in the State Department. This action is believed by Dillon to be an excellent move because the Department has the power of the State to enforce its rulings and to protect the dealers who buy the milk for distribution. This plan is most radical and whether it will succeed or not will be observed with interest. That it should be

thought of indicates deep dissatisfaction with the methods that have been in vogue.

Among milk consumers the suspicion is rife that some one is getting undue profits out of the milk business but whether their mistrust is warranted or not they are unable to tell for they know nothing about the cost of milk production, or of transporting milk and the contractors have given little information as to the cost of conducting their part of the business.

It is the contractor's contention that the price of milk is fixed only by supply and demand, that the similarity of schedule is to be expected because the producers are all thoroughly familiar with the market and the scale of prices is merely a reflection of their opinion of it. Contractors admit that the trade of small dealers is from time to time absorbed, but they contend that this is because the milk business naturally lends itself to monopoly, because the expenses of conducting a small business are great as compared with that of conducting a large one, and they assert that they are receiving a very moderate return for the capital they have invested.

**Methods of Paying Producers.**—The dealer's check is sent the dairyman weekly, monthly for the previous month, or payment for a month's milk is withheld for longer periods; in some cases dealers are habitually 2 or 3 months in arrears to the dairyman. In many instances these delinquent dealers fail, which has led some States to enact laws compelling contractors to file bonds to secure their purchases of milk and cream.

**Milk Plants.**—Milk companies build stations or plants for handling milk and preparing it for delivery. These plants are developments of the milk room or milk house that are part of the equipment of dairymen who retail their own milk. Originally such houses were merely convenient places to work and for storing milk in tanks filled with well or spring water. Sometimes, if dairymen made butter, the houses were equipped with churns. Later, milk coolers, bottlers and separators appeared and the dairymen had to meet the problems of drainage, disposal of wastes, etc.; in fact these milk houses became stations in miniature.

Milk stations may be divided into two classes according to whether they are located in the country or the city. The processes through which milk is put in the two classes of plants are much alike, the principal difference being in the scale on which they are conducted. So the detailed discussion of them that follows in the account of city plants is intended to cover both.

**Country Milk Plants.**—Country plants in different parts of the United States are given divers names being variously called creameries, milk-receiving depots, bottling plants and shipping stations. They are usually owned and operated by city milk contractors, but in some instances by farmers. In response to the latest development in the city milk trade

country milk plants have multiplied; some have been created by remodeling old creameries while others are new, being designed and built for the special purpose for which they are used. There are several advantages in the country milk plant system. As a rule it is not necessary to invest so much money in country as in city plants; usually from $2,000 to $20,000 according to the character of the building and its equipment is enough. However, if a contractor buys his milk in several widely separated dis-

FIG. 39.—Country milk plant at Harvard, Illinois.

tricts it often is more economical to concentrate his business in a single city plant than to maintain several country plants. Labor difficulties are less likely to occur, for the men in the country can live more comfortably on their wages than men in the city can on theirs and it is more difficult to foment strife among employees scattered in small numbers in several plants than it is to do so in a large plant with many on the payroll. Dairymen dealing directly with the plant managers get on more harmoniously than they do with officials living in the city whom they seldom see. The country milk plant effects a desirable concentration of country business for either by a system of auto truck collection or of having dairymen haul directly to the plant, the unsatisfactory practice of leaving a few cans of milk exposed on the platform of little way stations to be picked up by milk trains is abolished. Country plants facilitate the grading of milk which is becoming a powerful factor in improving dairying.

**The Item of the Surplus.**—It is the opinion of many that surplus milk is better handled in the country than in the city. The production of milk is at the maximum during June and decreases gradually through

the succeeding months, but in general there is no fluctuation from day to day in the yield of the cows except in response to severe weather conditions such as extreme cold or heat or a parching drought. Cows yield steadily, though in declining amounts as the lactation period progresses. The demand for milk, on the contrary vacillates; in hot days more milk is used than on cold ones and on stormy days the amount sold in stores is less than in fair weather. Many families go away for Saturday and

*Courtesy of Robert Burnett.*

Fig. 40.—Country milk plant of Deerfoot Farms, Southboro, Mass.

Sunday and in vacation time 10 to 60 per cent. of the trade leaves certain parts of the city. Consequently, the dealer, since his contract compels him to take the full quantity of milk named in the agreement, often finds himself with milk over and above what can be disposed of, sometimes to the amount of 2 days' supply, and occasionally also he faces a shortage of milk which can only be made up by purchasing a temporary supply at high price in a territory that very likely is far away, thus imposing unusual transportation charges. In times of a surplus the only way to prevent serious losses is to manufacture the milk into butter, cheese and other dairy byproducts, but since milk of the grade that goes into city milk supply commands a price higher than can be realized from the manufactured products, at best, the loss can only be minimized. Unfortunately the surplus is most likely to occur when bottom prices for butter and cheese prevail so that loss is almost inevitable. Peck states that the Abbot's Alderney Dairies of Philadelphia for 20 years have kept books in such a way as to show the cost of this factor of supply and demand that this company finds the loss to approach $0.005 per quart on entire sales. As instances of sudden shrinkage of the milk supply he cites actual

losses experienced by the Sheffield Farms-Slawson, Decker Co. of New York and by the Bowman Dairy Co. of Chicago in the summer of 1913. The shrinkage in the supply of the former company on July 10 to July 11 was 13,145 lb. and from July 13 to July 14 was 18,460 lb.; coincidently, the increase in orders from July 11 to July 12 was 10,170 lb. The total amount of milk purchased to make up shortage in July was 792,655 lb. and in August 3,558,865 lb., making the cost over the regular price of milk $15,367.96. The latter company experienced a milk shrinkage on July 30 to July 31 of 15,406 lb., on Aug. 8 to Aug. 9 of 20,339 lb., and on Sept. 19 to Sept. 22, of 29,850 lb. The total shrinkage in this milk supply from July 10 to Sept. 22 was 211,834 lb.

H. P. Hood and Sons of Boston state that in March, 1911, it was possible for them to dispose of but 61.5 per cent. of the milk bought, leaving 38.5 per cent. to be worked up into butter and casein but that in November purchases and sales balanced. This firm estimates that in a series of years 20 per cent. of the milk purchased will have to be made up into butter and casein.

It should be readily appreciated that this item of the surplus presents a most serious difficulty. In the last analysis the cost of caring for it falls on the milk consumer but its first effects come more directly on the dealer who has to finance the loss for the time being. There is temptation for a dealer who finds himself oversupplied with milk to resort to rate cutting which, if yielded to, upsets business and in the long run has a bad effect that is felt by all. The burden of carrying this surplus is best adjusted by working up the extra milk so as to obtain for it the best possible price. By doing the manufacturing in the country the cost of transportation of the milk at least is saved.

**The North System.**—However, the chief reason for maintenance of country milk plants is found in the vital principle of the North system, namely, that a single central plant is needed in the dairy district to cool, pasteurize, standardize and store the milk and to clean and sterilize the tinware used by the farmers, it being unreasonable to expect them to do this work because they have not the training for it and because of the unnecessary expense that would be incurred should each farmer invest in the requisite apparatus and expend time and labor in preparing his milk for market that can be greatly economized by handling the milk of all the farmers together. In fine, better milk is obtained through the country milk plant system than under that of city plants. In some cities like Chicago with the dairy districts at their very gates the city plants have largely disappeared, practically all of the milk being shipped in bottles from the country to the city.

**Handling of Milk in Country Plants.**—The operations milk goes through in country plants varies a great deal according to whether the milk receives merely preliminary treatment for shipment to city plants where

it receives final preparation for the market or whether the milk is made ready for city delivery. Country plants may be simply receiving stations where the milk is weighed, cooled, recanned and loaded into cars or they may be very completely equipped stations where the milk is weighed and clarified, after which part is separated to get the cream requisite for city consumption and for use in standardizing the rest. After standardization, the milk is canned without pasteurization or after having gone through this process is canned or bottled and then cooled to between 40° to 50°F., finally being loaded onto the cars. The skim-milk is utilized in various ways; it may be sold back to the farmers for feeding to stock in which case it should always be pasteurized to prevent the dissemination of tuberculosis and other diseases among the animals or the casein may be precipitated with dilute acids and sold to concerns that manufacture it into size and other products. In some country milk plants by the use of bacterial cultures milk beverages such as buttermilk, koumyss and others are made from the skim-milk.

**Cream.**—Cream is sent to the city market with varying butterfat content under trade names such as No. 9, No. 17, single, double, coffee, light creams, etc., that have no exact meaning but that convey to the customer the idea that the creams are of different richness. Thus one dealer's light cream may contain 12 per cent. butterfat, another's 15 per cent. and still another 17 per cent., their double creams will be much richer but improbably twice as rich and they will differ in like manner from one another in butterfat content. The separator makes it easy to control the percentage of butterfat in cream for it is so constructed that by adjusting the cream screw the milk may be closely or lightly skimmed. Also from a heavy cream, one of any desired lower butterfat content can be made up by adding either whole or skim-milk in proper proportion. Of late years there has been marked increase in the demand for cream, not only for manufacture into ice cream and other dairy products, but for preparing fancy dishes in hotels and for family use so that the sale of sweet cream has become an important part of the city milk business. In some markets the price of cream actually determines the price of milk. Sometimes country milk plants are wholly devoted to the preparation and shipping of sweet cream. In such plants the milk is separated, the cream pasteurized, cooled, canned and loaded into cars while the skim-milk is worked up separately.

**The Cream Separator.**—The separator is to be found on many dairy farms and in most milk plants, in fact it is all but indispensable to everyone who sells milk and cream. By the separator, milk can be more rapidly and efficiently skimmed than by gravity; the richness of the cream can be controlled and the separation can be done at any time so that waiting for the cream to rise is unnecessary. The separator works on the centrifugal principle. The whole milk enters a revolving bowl

and the heavy particles are thrown to the outside wall making the skim-milk, while the lighter particles, the butterfat, remain in the center forming the cream. Bowls are run at a high rate of speed, those of small diameter turning fastest; some make 16,000 r.p.m. Within the bowl are discs or leaves over which the milk spreads in thin films as it enters so that it is quickly given a centrifugal motion and the separation of the cream accelerated accordingly. In some types of separators a revolving flange gives a rotary impulse to the incoming milk with the same result. The length of time the milk remains in the bowl is determined by the obstructions therein. There are a number of things that effect the efficiency of the skimming process, viz.:

1. The speed of the bowl.
2. The steadiness of the bowl.
3. The temperature of the milk.
4. Rate of skimming.
5. Richness of the cream.
6. Acidity of the cream.
7. Character of the milk, due to breed of cow, stage of lactation and the richness of the milk.

The richness of the cream is controlled by the cream screw in the separator bowl; turning the screw toward the center of the bowl throttles the outlet and increases the richness of the cream, and turning it away from the center opens the outlet and makes the cream thinner.

With the increase of speed more skim-milk is forced out the openings, making the cream richer; the effect of the speed is more marked when the cream screw is set to deliver a high percentage of fat. The rate of inflow of the milk is affected by the speed of the bowl because the higher the speed the greater the tendency to produce a partial vacuum in the revolving bowl. As a rule when the separator is run at three-fourths its normal speed the loss in skim-milk is two to three times as great as when it is run at the indicated rate. Machines usually leave the factory adjusted so that 10 per cent. of the milk put in comes out as cream.

The separator should run smoothly for all vibration or jarring increases the loss in fat. For this reason the separator should set level and be mounted on a rigid foundation. An unbalanced bowl or loose or dirty bearings cause the separator to run unevenly.

The temperature of the milk at skimming is important; it should be between 90° and 100°F. The effect of reducing the temperature of the milk below this is to increase the percentage of butterfat in the skim-milk. Between 70° and 80°F. there is an appreciable loss of butterfat and at lower temperatures it is serious. The loss is caused by the greater viscosity of the cream at low temperatures which makes it pass slowly through the outlet of the bowl. The milk can be so cold that the separator will not deliver the cream.

A change in the rate of inflow of the milk changes the ratio of skim-milk to cream for while a diminution in the inflow reduces both the milk and cream, the latter is most affected so that decreasing the inflow reduces the percentage of fat in cream.

High acidity of the milk reduces the cream.

The percentage of fat in the cream varies directly with the percentage of fat in the whole milk. The size of the fat globules varies with the breed of the cow and the larger the globules the more readily the milk skims. It is because of the large proportion of small globules in milk at the end of the lactation period that strippers' milk does not skim well.

The separator should be properly cared for in order that the milk which is run through it may be uninjured and that the separator may last long.

A great deal of harm has been done butter manufacturers and city milk dealers by unscrupulous agents of separator companies representing to farmers that the particular machine they were touting was so easy to clean that but little time need be spent in washing it; in many instances it has been stated that the machine might be sufficiently cleaned by merely running water through it at the end of the separating. Such statements are grossly untrue and if the advice is followed must inevitably result in the production of inferior milk and cream. Milk clings to the bowl parts of the separator and only patient and thorough cleaning will remove it. If the least bit of milk is left adherent it will serve as food for bacterial growths that will contaminate the milk as it is run through the separator. The separator should be flushed with cold water at the end of the run; then it should be taken apart and the parts washed, first in cold water then in hot water and washing powder and finally they should be rinsed. Then they should be hung up in a light airy place to dry until needed again. If the parts are put together in the machine they are likely to rust. Where there are facilities for doing so, the parts should be sterilized before use.

Separators must be kept in good order or they will wear out more quickly than they should. The gearings should be flushed once a month with a good grade of kerosene and then reoiled with lubricating oil.

In purchasing a separator attention should be paid to the following points:

1. Capacity; the machine should be large enough.
2. Cost; a cheap machine is a poor investment.
3. Durability; standard machines are most likely to give good service.
4. Ease of cleaning is highly important; the more simple the bowl device the better.
5. Spindle; whether attached or detached. Most standard machines have detached spindles which prevents them getting out of line.
6. Oiling system; an important feature for the machine should be kept well-oiled with the gears bathed in oil.
7. Speed of the machine.
8. Efficiency.

**Advantages of City Milk Plants.**—The system of building milk plants in the city is older than that of locating them in the country; it had its origin in the simple fact that the first city dealers had to have a place to care for the milk they received from the country and headquarters for the transaction of business. As business grew, so did the plants, for more space was required for handling the milk and for years there was no attempt of the contractor to extend his operations into the country. In time, however, country plants were developed, largely because certain firms that were making condensed milk and that were also in the city milk business found a portion of the latter could be profitably carried on from the dairy centers they had built up around their condenseries. This led to a comparison of the merits of country and of city milk plants. In favor of the latter it was found that the business of several dairy districts can be concentrated in a single plant and that they possessed certain other advantages. Milk cars will not hold as many gallons of bottled milk as of milk in cans and the glass bottles and cases weigh more than the cans required for an equal quantity of milk, consequently it costs more per pound to transport bottled milk than bulk milk. The outlay for bottles and cases is necessarily greater when milk is shipped in bottles than when in cans for there must be in addition to the bottles and cases required for daily delivery in the city enough more in transit to assure an adequate supply in both city and country. As there is more glassware in daily circulation the breakage bill is higher in the system of country plants. Broadly speaking small country plants are not run on such a high plane of efficiency or at such low cost as large city ones. There is a saving of time in the city from having the milk arrive from the country bottled and ready for distribution but this is offset by the delay at the country end that may arise from irregular delivery of milk at the plant by the farmers and certainly does so from the fact that small pasteurizing units cannot handle the output as rapidly as large ones. Moreover, interruption of service either through breaking down of the machinery or other causes may be serious enough to make the milk miss the train entirely which is not likely to occur when the milk is shipped in cans to city plants. Thus the milk available for city delivery may be curtailed, and inconvenience the customer, with consequent loss of trade to the contractor, whereas if the milk train is late the worst that is likely to happen is the loss of a few hours time in the plants. However, by good management many country milk plants are regularly supplying milk to the city without interruptions occurring. City plants, too, have perhaps been unconsciously favored by boards of health because at less cost a more constant and so a more thorough supervision can be maintained over them than over country plants.

**General Features of City Milk Plants.**—City milk plants are usually located near railroad terminals but there is developing a tendency to

place them in the center of the territory of distribution. They are often rambling structures that in many cases housed the contractors business when it was small and required little machinery and have been enlarged as the growth of the business required, by the purchase and addition of adjoining structures and by the building of annexes. So these plants are only indifferently adapted to the business. In fact, one of the things that has delayed the introduction of cost accounting into the city milk business has been these very plants for they necessitate the shifting of employees from job to job in a way that baffled all attempts at good management and accurate keeping of time. Of late years there have been erected in Milwaukee, Indianapolis, Philadelphia, New York and other cities plants that are especially designed for the city milk business. No expense has been spared. Their sites are carefully chosen; they are marvels of sanitary construction; contain the latest machinery for preparing milk for delivery to the consumer and for handling it in the most orderly, rapid and economical manner. The buildings contain huge vats for mixing and storing the milk, machines for clarifying, pasteurizing and bottling it, apparatus for making butter, cheese, milk beverages and homogenized milk, repair shops, laundries, and power plants for making steam and driving the machinery. There are also chemical and bacteriological laboratories besides lunch rooms for the employees, rooms for the drivers to use when making up their accounts, offices for the officials and clerical force, garages, wagon sheds, stables and smithies. To one who has never visited these large city milk plants it is difficult to comprehend the scale on which the business is done. What for the time being will be the largest of them all is to be erected in New York City in 1916. It will be a six-story plant having a frontage of 252 ft. and a depth of from 100 to 125 ft. The cost of the building alone will be $300,000; it will have a refrigerating plant of a daily capacity of 12,000 tons and will employ 125 to 150 men. In most of these large plants are stores for the sale of milk and dairy products as well as of eggs which are often handled as a side line by city milk dealers. Sometimes cafeterias where dairy lunches are served are established. The milk business is absorptive in character and some of the large dairy companies become real or virtual owners of restaurants, ice-cream factories, confectionery establishments, bakeries, etc.

These huge milk plants can be supported only by the great metropolitan centers but their advantages are so great that even in the smaller cities similar but smaller plants have been built. A single plant may be capable of handling the entire business of such places but sometimes competing firms each put up a plant with the result that neither thrives. More commonly the first company to build secures a monopoly of the best part of the business through its ability to pasteurize the milk, give it adequate cold storage and to serve the public promptly. Many boards

of health would like to pass ordinances requiring that all or a part of the milk should be pasteurized but are deterred from doing so by the fact that such an ordinance might put some men of a moderate amount of capital out of business and might tend to drive a part of the business of others to the large plant already equipped to pasteurize. Also there are cities which have no milk plant, that might support one if the milk of all the dealers could be handled in a single plant. Out of these conditions has grown the demand on the part of the public that the dealers shall get together and erect a plant where all the milk shall be pasteurized, cooled and stored or that a municipal plant shall be put up for the purpose. Competition in the milk trade is so very keen that it no doubt will be difficult to get dairymen to assent to either plan but there is strength in the movement and it may succeed.

The preparation of milk for the market varies in different city milk plants. The smallest are merely depots where raw milk is received, bottled and held at low temperature for delivery. In the largest, milk is tested for odors, and flavor, and sediment, at the receiving platforms and then dumped into mixing vats from which it passes through the clarifier into standardizing vats where it is brought to the butterfat test which the contractor has determined the milk he puts out to his trade shall have. If the milk is not to be used at once it then goes to insulated cold storage tanks where it is kept at low temperature until it is needed. Milk from the standardizing vats or the storage tanks is pasteurized after which it is put into cans for the wholesale, or into bottles for the retail trade. It is then cooled at once to between 35° and 50°F. and kept in refrigerators or cold rooms till wanted for delivery. Most of the large plants are equipped for the manufacture of milk beverages and for working up the milk that is returned on the delivery wagons and all other surplus milk, as butter and cheese.

**Classification of City Milk Plants.**—There no doubt is some difference of opinion as to what sort of an establishment may properly be called a city milk plant for some would restrict the term to plants that represent a large investment of capital and handle large volumes of milk while others would apply the term more generally. It seems that the name may be given to any place where a regular business of preparing milk for the retail trade is carried on. Accepting this view city milk plants may be placed in two groups as follows:

**Group 1.**—Single-story plants: plants occupying a basement only; plants occupying a ground floor and basement; plants occupying the ground floor only.

**Group 2.**—Plants of more than one story.

**Basement Plants.**—Basement plants may be perfectly sanitary but few are so. As a rule they are operated by small dealers with inadequate capital and are located in the dealer's dwelling or in the buildings whose

principal use is for some other purpose than the milk business. Both of these conditions are bad; in the one case the appearance of infectious disease in the household will cripple the business, and the inevitable constant communication between the family and the dairy tends to make the basement dirty and smelly with the result that the milk becomes tainted with unpleasant odors; in the other the most incongruous sorts of business are carried on under the same roof with the milkman's. Basement rooms are difficult to light, ventilate and keep free from odors. Street dust polluted with animal excretions gravitate naturally to the basement. Often basement rooms are not ceiled and dust sifts down through cracks in the floor above, or even, if there is a ceiling, it is likely to be rough and cracked and therefore a source of dirt rather than an aid in cleanliness. The plumbing in the building may be defective and so admit odors. Basement windows are not easily kept clean and rubbish often accumulates against them. As the equipment of all city milk plants is determined by the volume of trade, these basement plants, since they do a small business, are apt to be underequipped and such apparatus as they do have is likely to be rather primitive and often badly worn. So in general it is the policy of boards of health to eliminate depots of this type.

**Ground-floor and Basement Plants.**—Plants of the ground-floor and basement type are often of considerable size. In some instances the basements may be of such a sort as to invite serious criticism; in others they are all right. In plants of this kind the milk is sampled at the receiving platform, weighed in a can sunk in the floor from which it is run into a vat in the basement. Thence it is pumped to pasteurizing machines on the ground floor. The pumps, and the piping connected thereto are difficult to clean and on that score are objectionable. On the ground floor the milk may be pumped from machine to machine or the several machines may be located on platforms one above another so that milk can flow by gravity through the series. For example, from the mixing tanks in the basement milk may be pumped to the pasteurizer on the highest platform, pass through it and flow over the cooler on the next lower platform and thence into the bottler on the lowest platform of all.

**Single-story Plants.**—In plants that are all on the ground floor the milk is pumped from one machine to another, several pumps being utilized for the purpose.

**Plants of More Than One Story.**—Plants of the second group, that is of two stories or more, usually belong to large dairy companies and represent very large investments of capital. Milk is received on the ground floor and is sometimes dumped into tanks and raised to the top of the building by pumps but as they are somewhat difficult to clean, it usually is hoisted in the delivery cans to the highest story and dumped there. Thence it is carried from one process of handling to another downward by gravity from story to story till it reaches the ground floor again, all cased and ready for delivery.

**Minimum Requirements for a City Milk Plant.**—Sooner or later in every city the question arises as to what the law shall require in the simplest and least expensive milk plants. The answer which the practical experience of those cities that have studied the problem seems to give is that these plants should have at least three rooms, namely; a boiler room, a washroom and a milk-handling room with refrigerators or other provision for keeping the milk cool. The arrangement of these plants should be such that the dirt of the boiler room shall be confined there and that the bottling room shall be effectively isolated from the litter, steam and odors of the washroom.

**Environment of the Milk Plant.**—With these general observations on country and city milk plants we may proceed to more particular consideration of city plants and the handling of milk therein. In the first place, it should be noted that the environment of a milk plant is important; it should be put where it will be as free as possible from contaminating surroundings. Badly built latrines, hog pens, chicken yards, manure heaps and surface drains carrying slops and excrementitious matter are all to be avoided. There should be abundance of sunlight because work can be better and more cheerily done in a well-lighted plant than in a dark one, because sunlight has some disinfecting value and because of the advertising value that good lighting has. One of the large plants of the central west is widely known as the "sunlight dairy" and a large contractor in Philadelphia makes an attractive appeal to the public through a picture showing the situation of his plant next to a fine public park. Pure air is essential; to locate a plant in a district where noisome odors prevail is poor policy and it is important that the air be free from dust. Unpaved streets are usually very dusty and so are to be avoided in choosing the site for a milk plant as, for the same reasons, are the much-traveled thoroughfares of the city. However, the plant must be where these main avenues of distribution and the lines over which the milk comes to the city are easily and quickly reached. In some of the large cities the air entering the plants is filtered or washed.

**General Plan of the Milk Plant.**—The layout of a plant should be such that the milk can be handled with ease, certainty, and economy. A poorly designed plant results in unnecessary labor and expense because it compels extra handling of the milk and long time-consuming trips from one part of the building to another. In small plants there should be a separate washroom, boiler room, milk-handling room and refrigerating room. Large plants should have a boiler room or power plant, a receiving room, washroom, milk-handling room, refrigerating room and sales room. The rooms for receiving and for handling the milk should have a minimum of piping. The absence of toilet conveniences for the employees should be regarded as a serious defect but water closets should not communicate with any room in which milk is handled; latrines should be 100 ft. from

the building and should have flyproof and ratproof vaults. No room used for domestic purposes should be directly connected to the milk plant. The horse stable should be entirely separate from the plant.

**Water Supply of the Milk Plant.**—The water supply should be abundant, clean and safe. When the public water supply is used the bacteriological and sanitary chemical analyses of the city or State are usually available and can be depended upon. It will usually be found economical to have in addition a mineral analysis of the water with the analyst's statement of how the water should be corrected for boiler use. This is particularly necessary in regions of hard or corrosive waters. The contractor who depends on the advice of salesmen of boiler compounds in the purchase of correctives is likely to be badly deceived. Where the contractor develops a private water supply for his plant he should have periodical bacteriological and chemical analyses made of the water and should keep them carefully on file that he may have them as a defense in case the purity of the water is impugned.

**Plumbing of the Milk Plant.**—The plumbing of the building is important. Sanitary open plumbing should be used and the workmanship should be first-class. The fixtures should be conveniently placed but toilets should not open off rooms in which milk is handled. The system should be designed in such a way that there will be little trouble from freezing. Pipes should be wrapped to prevent them from freezing or in the case of long leads of hot water piping, to prevent loss of heat. Fixtures should be properly trapped and the main soil pipe should be carried up through the roof above the ridge.

The wash bowls may be of marble, porcelain or of enamel ware. The sinks in which bottles and tinware are washed are generally of galvanized steel. Wood and soapstone are absorptive and so should not be used. In the smaller dairies of the better class porcelain sinks are sometimes used for washing bottles. They are expensive but otherwise they are excellent.

**Cost and Equipment of the Milk Plant.**—In construction it should be borne in mind that the plant should perform its function efficiently and at low cost. The dealer who erects an unnecessarily expensive plant imposes a burden on the business in the same way that the producer does who builds a highly expensive barn. The land chosen for a site should not be overvaluable. The building itself should be planned with a view to the future of the business; it should be so designed that, as convenient, additions can be made and it should be durable and perfectly sanitary.

**U. S. Department of Agriculture Milk Plant Score Card.**—A correct conception of the essential features of a first-class plant is best obtained by studying the score card for city milk plant inspection, of the dairy division of the U. S. Department of Agriculture.

### Milk Plant Score Card

| Equipment | Score: Perfect | Score: Allowed | Methods | Score: Perfect | Score: Allowed |
|---|---|---|---|---|---|
| Building: | | | Building: | | |
| Location: Free from contaminating | | | Cleanliness: | 14 | ...... |
| surroundings | 2 | ...... | Floors 3 | | |
| | | | Walls 2 | | |
| Arrangement | 7 | ...... | Ceilings 2 | | |
| Separate receiving room 1 | | | Doors and windows 1 | | |
| Separate handling room 2 | | | Shafting, pulleys, pipes, etc. 1 | | |
| Separate washroom 1 | | | Freedom from odors 2 | | |
| Separate sales room 1 | | | Freedom from flies 3 | | |
| Separate boiler room 1 | | | Apparatus | 7 | ...... |
| Separate refrigerator room 1 | | | Cleanliness: | | |
| Construction | 12 | ...... | Thoroughly washed and rinsed. 3 | | |
| Floors tight, sound, cleanable 2 | | | Milk-handling machinery 2 | | |
| Walls tight, smooth, cleanable 1 | | | Pipes, cans, etc 1 | | |
| Ceilings smooth, tight, cleanable 1 | | | Sterilized with live steam 3 | | |
| Drainage 2 | | | Milk-handling machinery 2 | | |
| Floors 1 | | | Pipes, cans, etc 1 | | |
| Sewer or septic tank 1 | | | Protected from comtamination 1 | | |
| Provision for light 2 | | | Bottles | 7 | ...... |
| (10 per cent. of floor space.) | | | Thoroughly washed and rinsed 3 | | |
| Provision for pure air 2 | | | Sterilized with steam 15 min 3 | | |
| Screens 1 | | | Inverted in clean place 1 | | |
| Minimum of shafting, pulleys, | | | Handling milk | 22 | ...... |
| hangers, exposed pipes, etc. 1 | | | Received below 50°F 3 | | |
| Apparatus | 15 | ...... | (50° to 55°, 2.) | | |
| Boiler 2 | | | (55° to 60°, 1.) | | |
| (Water heater, 1.) | | | Rapidity of handling 2 | | |
| Appliances for cleansing utensils | | | Freedom from undue exposure to | | |
| and bottles 2 | | | air 2 | | |
| Sterilizers for bottles, etc 2 | | | Cooling 5 | | |
| Bottling machine 1 | | | Promptness 2 | | |
| Capping machine 1 | | | Below 45°F 3 | | |
| Wash bowl, soap, and towel in | | | (45° to 50°, 1.) | | |
| handling room 1 | | | Capping bottles by machine 2 | | |
| Condition 6 | | | Bottle top protected by cover 1 | | |
| Milk-handling machinery 3 | | | Storage; below 45°F 4 | | |
| Pipes, couplings, and pumps 2 | | | (45° to 50°, 3; 50° to 55°, 1.) | | |
| Cans 1 | | | Protection during delivery 2 | | |
| Laboratory and equipment | 2 | ...... | (Iced in summer.) | | |
| Water supply | 2 | ...... | Bottle caps sterilized 1 | | |
| Clean and fresh 1 | | | Inspection | 6 | |
| Convenient and abundant 1 | | | Bacteriological work 3 | | |
| | | | Inspection of dairies supplying | | |
| | | | milk 3 | | |
| | | | (2 times a year, 2; once a year, 1.) | | |
| | | | Miscellaneous | 4 | ...... |
| | | | Cleanliness of attendants 2 | | |
| | | | (Personal cleanliness, 1; clean, | | |
| | | | washable clothing, 1.) | | |
| | | | Cleanliness of delivery outfit 2 | | |
| Total | 40 | ...... | Total | 60 | ...... |

Score for equipment............plus score for methods............equals total score............

Note.—If the conditions in any particular are so exceptionally bad as to be inadequately expressed by a score of "0" the inspector can make a deduction from the total score.

It allows 40 points for equipment and 60 points for methods. This estimate of the relative importance of the two is instructive and should be taken to heart by all managers of milk plants. There are too many who feel that a fine building equipped with expensive apparatus will turn out a clean safe milk without any particular effort on their part to insure its doing so. The fact is that unless the building is kept scrupulously neat and the apparatus perfectly clean and sterile and unless the milk is handled properly it is likely to be the worse for the treatment it receives. The apparatus needs particular attention; it is somewhat complicated and the milk naturally sticks to it so that unless the utmost vigilance is exercised it is bound to become unclean. Milk picks up germs from whatever it comes into touch, so that dirty apparatus seeds it with bacteria. Undue exposure to the air, especially if it is dusty, does likewise. If in addition the milk is not promptly handled and cooled, the bacteria have an excellent opportunity to grow and spoil the milk. Elaborate equipment does not necessarily mean excellent or even good milk, as many health officers have learned to their sorrow, from having to wrestle with big expensive plants that owing to indifferent management turn out a mediocre product. The contractor who expects his milk plant to run itself is foredoomed to failure. As the committee on Milk Plant Inspection of the International Association of Dairy and Milk Inspectors puts it, "attractive, well-equipped plants are no indication of the quality of milk that is being sold; the milk going through the plant must be of good quality to begin with and must be handled properly."

Under equipment, the card allows 21 points for building and construction and 15 points for apparatus. For the building reinforced-concrete construction is excellent. The walls and ceilings should preferably be of tile or brick; they should be sheathed, made dust proof and painted a light color if these materials are not used. The window space should be at least 10 per cent. and ought to be 20 per cent. of the floor space. Provision should be made for screening the windows and outside doors; the latter should have automatic closing devices. Throughout the plant the ceilings and walls should be smooth, tight and cleanable. Window sills, projecting window frames, door frames and other places where dust can settle are objectionable. As in handling the milk, more or less is spilled on the floors and as in cleaning much water is flowed over them it is important that cement or some other impervious material should be used in their construction. Iron plates set flush in cement give good satisfaction. The plates should be used wherever cans are rolled about much. Care should be exercised to keep the floors free from cracks because the washings accumulate sour milk and filth in them; sometimes considerable drainage escapes through them and creates beneath the floor a rather extensive stinking area. Floors should be sloped from the walls to a drain in the center which should be trapped and carried to the public sewer, a

filter bed or septic tank. Small plants can usually be ventilated by windows; large ones may need some system of artificial ventilation. In any plant it is desirable to conduct the different operations in separate rooms but in the smallest this is impossible. Even in these a separate room for handling the milk is a necessity. It should be located away from the ashes and soot of the boiler room and be so built that it can be closed tightly to keep out steam and air vitiated with odors and dust. When the room is in use no one whose presence is not absolutely needed should be allowed in it.

Large plants should be completely equipped with apparatus but small ones cannot be. In general, proper equipment for a plant includes: steam boiler, appliances for cleaning the utensils and bottles, sterilizers for bottles and other apparatus, bottling and capping machines, proper piping, shafting, etc. for operating the plant, and washbowl, soap and towels for attendants in the milk-handling room.

All weigh cans, storage vats and other apparatus should be constructed of suitable metal, preferably tinned copper. Closely fitting covers of material similar to the apparatus should be provided and all angles and joints should be soldered smooth.

Pipes and pumps should be of sanitary construction and so arranged that they may be easily taken apart for cleaning. No tightly soldered elbow joints should be allowed.

Valves on bottling machines should be simple and so constructed that they may be easily taken apart and cleansed. Especially it is essential that the rubber valve seats shall be easily detachable.

Every milk plant should be equipped with a Babcock tester and large ones should have laboratories for chemical and bacteriological work.

Two points are allowed for laboratory and two for water supply. Under methods, the card gives 14 points for cleanliness of the building, 14 for cleanliness and sterilization of apparatus and bottles and 22 points for proper handling of the milk. Besides, 4 points are allowed for cleanliness of the attendants and delivery outfit, 3 for bacterial work and 3 for inspection of dairies. A dirty building will become malodorous and attract vermin; if it becomes grossly unclean the dust and dirt may contaminate the milk. It is highly important that apparatus be clean and sterile, otherwise bacterial pollution of the milk is bound to result. Apparatus is properly cleaned by first washing it in cool water, then in hot water and washing powder, then in a rinse of clean hot water, after which the apparatus should be sterilized with steam or if that be lacking in boiling water. Pumps and piping are washed by pumping water through them right after they are thrown out of service, after which they are taken apart for thorough cleansing and for sterilization. Rusted and battered apparatus cannot be cleaned and should be discarded. In case a milk plant is putting out milk of inferior quality to what might be ex-

pected of the dairies that supply it, an inspector is justified in having all apparatus taken apart for thorough inspection. The law should require milk plants to be equipped with apparatus for sterilizing bottles; so many epidemics have been caused by infected milk bottles that there should be no dallying with this question. Milk may be spoiled in the handling of it. The temperature at which it arrives at the plant is important; the card allows 3 points for milk below 50°F. and less, for milk between this temperature and 60° above which point nothing is given. The milk should be handled rapidly. The cans of milk should not be permitted to stand long on the receiving platforms or in the plant before mixing, pasteurizing, etc. If the milk is not pasteurized directly after standardizing it should be held in tanks jacketed with ice water or brine. Only the larger plants can afford bacteriological laboratories but even the smaller ones can have inspection of the dairies supplying the milk.

**Medical Inspection of the Employees.**—The importance of the attendants is beginning to be appreciated. It is not enough that they be merely good laborers; besides, they must have sound health, be clean and have decent habits. The menace that those who handle food may be to the public has only been recognized within the last decade for only within that time has it been appreciated that walking cases of communicable diseases are not rare, and the part played by bacillus carriers in spreading infection has been understood. In New York City in 1915 a law was enacted requiring that persons engaged in handling foods should hold a certificate of health from the health department of the city. In the medical examination of these persons several carriers were detected and certificates were withheld from them. Other cities have adopted similar laws and it is certain that as their importance becomes understood their enactment will become general.

The Bureau of Animal Industry in 1915 sent out 1,250 questionnaires to the health officials of cities of the United States having a population of 5,000 or more and received replies from about one-half of them. To the question

> "Do you require any systematic medical inspection of persons employed in milk plants, creameries, cheese factories, ice-cream factories and condenseries?"

46 replied yes and 473 no. A sick attendant may infect the milk by sneezing into it, the fine spray of his sputum carrying the germs or he may infect it with his fingers which if unclean may carry nasal, buccal, urinary or fecal discharges. Therefore, employees should be taught the danger of droplet infection and of unclean hands. Those who from severe colds or other causes are having violent coughing spells should be excused from duty while any employee with a chronic cough should be subjected to medical examination to make sure that he is not consumptive. The work of Coues suggests that the laborers in milk plants are prone to develop

sore throats, but his data does not indicate that these throats are in any way dangerous to milk consumers. However, some sore throats are so, for they may in reality be diphtheritic or of an infectious streptococcal nature. Diphtheria is certainly carried by milk and there is some evidence to indicate that employees of milk plants who were working when they had septic sore throat infected the milk with that disease. So, even mild throat affections may be of importance and need attention.

Some of the certified dairies pay a good deal of attention to the health of their employees. Campbell states that the certified dairies around Chicago began the medical inspection of their employees in November, 1912, and since then employees coming into contact with the milk have been examined at least once a month, except during the recent epidemic of aphthous fever when other arrangements had to be made. Only those who have been vaccinated are employed. Applicants for employment are questioned as to recent illness, as to whether they have had diphtheria, typhoid fever, or are subject to frequent tonsillitis. They are also asked whether they have recently been in contact with a sick person. Each applicant is examined for disease of the eyes, skin of the face, neck, arm and hands and the condition of the finger nails is noted. He is also given a careful physical examination for tuberculosis. Applicants showing signs of conjunctivitis, tuberculosis, syphilis or other venereal diseases, or any suppurative process or any disease of an infectious character, are rejected.

A card index of every employee on each farm is kept; the points recorded are the replies to 27 questions and the findings of physical examinations. A separate card index is kept of the monthly medical examination; 10 items are recorded, among them being the temperature, pulse, condition of the eyes, of the skin and of the throat.

Since November, 1912, 775 primary medical examinations, 1,975 medical examinations and 315 throat cultures have been made. Of the primary examinations 38 per cent. were of persons of foreign birth.

In most milk plants the superintendent has to rely on the uncertain method of accepting the man's own opinion as to whether he is fit to work or not. Typhoid and paratyphoid fevers are the communicable diseases most likely to be spread through the urine and feces. With these maladies, too, symptoms may be misleading or lacking so that the mildly sick do not attract attention and continue at work till the route is plainly infected which usually leads to their discovery. Also, there are carriers of diphtheria and probably of scarlet fever. So, every effort should be made to reduce as far as may be the danger from these diseases by instructing the employees as to the infective nature of the several discharges and by teaching them to keep their hands away from their faces and to wash after using the toilet. It is also important that they be made to understand that the milk should not come into contact with the hands; probably most of the men exercise proper care in this matter but

some do not and they should be corrected for their carelessness. It should be clearly understood that since the bottling and capping of milk, except when it is pasteurized in the bottle, is done subsequent to pasteurization there is opportunity for the milk to be infected by employees *after* it is pasteurized. Since the use of labor-saving devices reduces the number of employees in the plant it also reduces somewhat the chance of infection from the help.

**Platforms.**—While the receiving and loading platforms are allowed no points on the score card they are nevertheless important for the efficient and economical management of the plant requires that they be of ample size, well-placed and kept in good order. It is likewise important that the approaches to them be spacious so that the wagons and trucks may come and go without crowding and confusion. The layout of the plants determine the location of the platforms. In some plants a single platform running the full length of the building is used, the empty cans and bottles being left at the end near the receiving vats or elevator and washroom while the delivery wagons are loaded from the cold storage rooms at the other end. In other plants at the rear there is a receiving platform where the milk is brought and where empty cans and bottles are left, while near the cold storage room is a loading platform.

**Inspection of Plant.**—In inspecting city milk plants all of the milk entering them should be tested as to temperature and cleanliness and it should be sampled for bacteriological and chemical analyses. All apparatus, piping, pumps, etc., should be examined to see that everything is clean and in working order. The inspector should see that floors, walls and ceilings are clean; that in fly time the building is properly screened; that milk is handled with reasonable rapidity; that it is not unduly exposed to the air; that the milk is properly cooled and is stored at a temperature not above 45°F.; that attendants are personally clean and healthy and are wearing clean washable clothing; that delivery outfits are clean and that the milk is properly protected during delivery. Only covered delivery wagons should be permitted and all milk should be iced in hot weather. The temperature of the milk should not be allowed to rise above 50°F. Bacteria samples should be taken at frequent intervals from milk on the delivery wagons to check up the work of the plant. City milk plants should operate only under a revocable license system.

The inspection is defective unless a good system of records thereof is kept. Records should include application for permits to operate, copies of all scores and of all analyses made.

**Age of Milk on Arrival at Plant.**—The age of the milk when it reaches the milk plant varies. In country plants, since there is usually but one delivery a day, the evening milk is about 12 hr. and the morning 1 to 6 hr. old. In city plants the age of the milk from the various shipping points is very different, that arriving from a distance or over lines afford-

ing poor service being much older than that from nearby stations. The U. S. Department of Agriculture in 1914 found that the extremes in the age of the milk were 2 to 46 hr. in Washington, 4 to 16 hr. in Baltimore, 4 to 41 hr. in Philadelphia, 2 to 48 hr. in Boston and 4 to 40 hr. in Pittsburgh. The average age of the milk in the several cities is considerable under the maxima given. It is considerably higher in Philadelphia, Boston and Pittsburgh than in Washington and Baltimore because to the first three of these cities the milk comes from a greater distance and also because much of it goes through country milk plants. In Washington and Baltimore the refrigerating facilities in transit are poorer than they are for the other cities, hence the milk has to be fresher. In Philadelphia practically all of the milk is less than 30 hr. old on arrival. In Boston the milk that was 48 hr. old was but part of the supply of a single dealer.

In considering the age of milk it must be remembered that it is important, only because milk spoils as it grows old. Milk that is 24 hr. old is expected to be more decomposed than that 12 hr. old but in fact this is not always so. The decomposition of milk is effected by living organisms over which man has a certain amount of control for by taking pains he can limit the number that get into milk and by cooling it sufficiently he can arrest their growth and so retard the decomposition of the milk or in a sense prevent its ageing. A dirty milk, shipped in dirty cans, in a poorly iced car may age more in 12 hr. than a clean milk, in clean cans, in properly cooled cars may in 16.

**Tasting the Milk.**—When milk is delivered in bulk at the plant for preparation for the market, it is usually tasted and often is sampled to determine the sediment, the butterfat and perhaps the bacterial content. Some tasters take the milk into the mouth; others simply shake the cans vigorously and removing the cover quickly, take the odor. By either method unpleasant flavors and high acidity are detected with considerable certainty. Milk that is found off flavor is rejected; thus dealers are protected from complaining customers and from paying for milk that is unsaleable. Still, because bacterial growths develop in the milk after it has passed the tasters, it sometimes reaches the consumer with a disagreeable flavor. In the past, certain abuses were common in tasting and sampling the milk. Tasters drank from the cans or their covers, or tasted from spoons or ladles that without washing were used to stir and taste other cans; milk in the cans was in one way or another brought into contact with the hands and other insanitary practices were indulged in. Nowadays this sort of thing does not occur in the better plants but elsewhere it still persists.

**Drip Pans.**—After the cans of milk have been tasted and sampled they are dumped into the mixing vats, and the cans inverted over a drip pan so that the drainage may be caught and saved to be used in dairy manufactures.

**Washing of Cans.**—In some plants the cans are returned unwashed to the farmer which is a very short-sighted, pernicious practice because few dairy farmers have the facilities for properly cleaning them and tests show that the bacterial contamination that results from the use of insterile cans is serious. For instance, the U. S. Department of Agriculture found that cans which received only the ordinary washing and rinsing contained from 300,000 to 18,000,000 bacteria per cubic centimeter with an average of 46,000,000. So 10 gal. of milk put in one of these cans would have received an initial contamination of 100,000 bacteria per cubic centimeter. Pease, from an extensive study in New York State, became convinced that insterile cans were important factors in producing the high bacterial counts in the milk of New York City in summer. A milk plant letter of the U. S. Department of Agriculture tells of one milk dealer who, on finding that the cans washed in his plant contained as high as 20,000,000 bacteria, installed a more efficient washing machine with the result that the bacteria were cut down to less than 200,000 per can; moreover, undesirable bacterial forms that survived the old process were killed.

In small plants, cans are cleaned by hand. Where the washing is properly done, they are first rinsed in cold water, then scrubbed in hot water with washing powder and finally washed in clean hot water and steamed with live steam if it is available. In larger establishments a jet machine which successively forces sprays of cold water, hot water and steam into the cans is used. This ought to be, and in many plants actually is, followed by a blast of dry air to dry out the cans so that neither moist surfaces nor a puddle will be left in the can wherein bacteria will multiply and also to keep the cans from rusting. Another style of washing machine brushes out the can with hot water and washing powder after which the cans are rinsed and then steamed on a jet machine. Other effective types of machines are in use. The covers are washed in hot water and washing powder, rinsed and dried and put in the sterile cans. If the covers are not put in the cans at once the cans should be inverted and kept in a clean place where they are protected from dust, flies and other contaminations. Much stress is laid on this sterilization of the cans and the drying them out with hot air. Where this is properly done it is undoubtedly a good thing but in some plants the cans are hurried through the process at such a prodigious rate that one's doubts as to the efficacy of cleaning and sterilizing are raised, and in some cases these suspicions are not allayed by taking the odor of the inside of the cans when they arrive at the farm. It is not intended to criticize the principle of cleaning and sterilizing the cans at the plant, for doing so has in a large measure, corrected a flagrant sanitary dereliction, for the custom that formerly obtained of returning the cans in an unwashed condition to the farm was indefensible, but it is desired to point out that the work may be

so rushed that it fails in its object. A device that will insure the cans being exposed to the steam for a measured interval of time is needed.

**Dirt in Milk.**—The amount of dirt that is found in milk varies a great deal according to whether a small-top milk pail is used in milking and other sensible precautions to keep the dirt out are taken. Some figures that have been published show that the dried sediment in the milk of seven German cities varied from 3.8 to 13.5 mg. per liter; in Copenhagen, Denmark, the milk contained from 1 to 13 mg.; in certain Norwegian cities the sediment averaged 2.6 mg.; in Washington, D. C., some samples contained as high as 180 mg. In American cities the amount of visible dirt in milk, even as it is delivered to the consumer, is often very great as any one can tell for himself by gently lifting the bottle and examining the bottom. Evans at one time estimated that the citizens of Chicago receive 25 tons of dirt per year in their milk.

**Clarification of Milk.**—The cream separator is often used to clarify milk. As the milk passes through the machine practically all of the insoluble dirt, some casein, cellular débris from the udder and bacteria collect as a slime on the wall of the separator bowl. The separated cream and skim-milk are recombined by mixing them. In many instances the process has given satisfaction, in others it has not. In passing through the separator the clusters of fat globules are broken up and to some extent the globules themselves are disrupted. Consequently, the recombined milk does not show as sharp a cream line as the untreated milk which often leads customers to complain. The bacterial clumps and chains are broken by the passage of the milk through the separator so that the recombined milk and cream has a higher bacterial count than the unseparated milk. This process has been thought to injure the keeping qualities of the milk and the explanation therefor has been given that as individuals the bacteria multiply more rapidly than in aggregates. Such an explanation is theoretical and it has not been a universal experience that the clarified milk fails to keep.

Specially constructed machines called clarifiers have come into general use in large milk plants for removing the visible dirt from milk; besides this they abstract mineral salts, casein, cells from the udder and bacteria. The machines depend on the centrifugal principle but the cream is not separated in passing through them; hence the clarified milk creams normally. It has been claimed that in clarifying by these machines a notable removal of cells and bacteria is effected and that the milk is greatly improved thereby. Others are of the belief that the numbers of bacteria in the milk are increased by breaking up the clumps and chains of the organisms and that the keeping quality of the milk is impaired. It is the author's opinion that while these clarifiers always remove large numbers of bacteria and cells their effect on the bacterial content of the milk is not uniform, the numbers being sometimes increased, and other

times decreased; that more evidence is needed as regards the effect of the machine on the keeping quality of the milk; and that the best results are obtained when clarification is followed by pasteurization. It is also his opinion that the machines do greatest service in removing the dirt, hairs, and blood, which even under cleanly conditions and careful management get into milk in small amounts and which no one wishes to drink. The objection has been raised to these machines that in reality they are a fraud on the consumer in that by removing the visible dirt they mislead him into the belief that the milk has never been contaminated. This seems an extreme position to take, for every one knows that it is impossible to collect tons upon tons of milk for city delivery without some dirt accumulating in it, and on esthetical grounds it seems best to remove as much of it as possible. If the clarifiers show an unreasonable amount of dirt the remedy is to trace the dirty milk back to the country and shut the dairymen that are producing it out of the city till they are prepared

TABLE 76.—EFFECT OF CLARIFYING MILK ON THE BACTERIAL AND CELL COUNTS (BOSTON BIOCHEMICAL LABORATORY)

Machine A Working at 6,000 r.p.m.

| Date | Minutes elapsed after starting the run | Temperature of milk at sampling, °F. | Bacteria per cubic centimeter in unclarified milk | Bacteria per cubic centimeter in clarified milk | Average number of cells per field in unclarified milk | Average number of cells per field in clarified milk |
|---|---|---|---|---|---|---|
| May 14, 1915 | 5 | 80 | 1,700,000 | 1,900,000 | 17.0 | 9.0 |
| | 25 | 80 | 1,250,000 | 920,000 | 12.0 | 8.0 |
| | 35 | 85 | 950,000 | 1,500,000 | 17.0 | 4.0 |
| | 45 | 72 | 780,000 | 1,200,000 | 17.0 | 4.0 |
| | 47 | 74 | ............ | 1,330,000 | ......... | 13.0 |
| | | | Av. 1,170,000 | Av. 1,370,000 | Av. 15.7 | Av. 8.2 |
| May 18, 1915 | 20 | 80 | 360,000 | 360,000 | 4.0 | 2.2 |
| | 50 | 82 | 710,000 | 880,000 | 4.3 | 2.3 |
| | 65 | 78 | 950,000 | 960,000 | 13.0 | 3.4 |
| | 75 | 78 | 800,000 | 980,000 | 8.0 | 2.4 |
| | 85 | 83 | 750,000 | 850,000 | 6.3 | 1.2 |
| | 120 | 75 | 900,000 | 1,080,000 | 3.2 | 2.3 |
| | | | Av. 7,400,000 | Av. 851,000 | Av. 6.5 | Av. 2.1 |
| May 19, 1915 | 20 | 76 | 1,350,000 | 1,220,000 | 13.6 | 6.0 |
| | 50 | 74 | 1,600,000 | 1,300,000 | 6.8 | 5.4 |
| | 60 | 106 | 850,000 | 420,000 | 8.0 | 4.0 |
| | 115 | 96 | 950,000 | 500,000 | 7.0 | 5.0 |
| | | | Av. 1,187,000 | Av. 860,000 | Av. 8.8 | Av. 5.1 |
| May 20, 1915 | 20 | 98 | 410,000 | 270,000 | 7.0 | 4.0 |
| | 50 | 74 | 230,000 | 190,000 | 6.7 | 4.3 |
| | 80 | 80 | 600,000 | 580,000 | 27.6 | 10.5 |
| | 90 | 88 | 860,000 | 1,000,000 | 20.2 | 12.6 |
| | 100 | 78 | 660,000 | 500,000 | 18.2 | 12.0 |
| | 110 | 72 | 650,000 | 700,000 | 19.0 | 5.0 |
| | 115 | 78 | 750,000 | 610,000 | 17.0 | 1.0 |
| | | | Av. 594,285 | Av. 550,000 | Av. 15.1 | Av. 7.1 |

TABLE 76.—(*Continued*)

Machine B Working at 5,400 r.p.m.

| Date | Minutes elapsed after starting the run | Temperature of milk at sampling, °F. | Bacteria per cubic centimeter in unclarified milk | Bacteria per cubic centimeter in clarified milk | Average number of cells per field in unclarified milk | Average number of cells per field in clarified milk |
|---|---|---|---|---|---|---|
| May 14, 1915 | 5 | 78 | 1,100,000 | 650,000 | 11.0 | 3.0 |
| | 25 | 79 | 1,030,000 | 820,000 | 82.0 | 2.0 |
| | 35 | 85 | 600,000 | 1,010,000 | 9.0 | 5.0 |
| | 45 | 84 | 450,000 | 900,000 | 9.0 | 1.0 |
| | | | Av. 790,000 | Av. 845,000 | Av. 12.75 | Av. 2.75 |
| May 17, 1915 | 20 | 94 | 1,070,000 | 580,000 | 8.0 | 6.0 |
| | 60 | 88 | 780,000 | 980,000 | 11.0 | 9.0 |
| | 75 | 92 | 800,000 | 950,000 | 17.0 | 5.0 |
| | 80 | 88 | 1,150,000 | 780,000 | 4.0 | 4.0 |
| | 85 | 88 | 850,000 | 750,000 | 4.0 | 2.0 |
| | 90 | 90 | 900,000 | 1,400,000 | 24.0 | 4.0 |
| | | | Av. 925,000 | Av. 906,666 | Av. 12.5 | Av. 5.0 |
| May 19, 1915 | 20 | 92 | 900,000 | 800,000 | 5.7 | 1.1 |
| | 50 | 88 | 1,110,000 | 910,000 | 7.2 | 3.0 |
| | 60 | 90 | 780,000 | 660,000 | 6.8 | 3.0 |
| | 65 | 94 | 870,000 | 930,000 | 5.6 | 2.2 |
| | | | Av. 915,000 | Av. 825,000 | Av. 6.3 | Av. 5.0 |
| May 21, 1915 | 20 | 86 | 200,000 | 180,000 | 14.5 | 14.0 |
| | 50 | 74 | 90,000 | 130,000 | 14.0 | 13.0 |
| | 70 | 78 | 280,000 | 240,000 | 13.0 | 11.0 |
| | 85 | 80 | 130,000 | 170,000 | 14.7 | 11.8 |
| | 95 | 80 | 550,000 | 750,000 | 19.0 | 17.0 |
| | 105 | 72 | 760,000 | 820,000 | 22.0 | 19.0 |
| | | | Av. 335,000 | Av. 381,666 | Av. 16.2 | Av. 14.3 |

TABLE 77.—RESULTS OF CHEMICAL ANALYSIS OF CLARIFIER SLIME (BOSTON BIOCHEMICAL LABORATORY)

Machine A

| Date | Weight in grams of samples taken for analysis | Moisture, per cent. | Ash, per cent. | Fat, per cent. | Casein on moist sample | Casein on dry sample |
|---|---|---|---|---|---|---|
| May 18, 1915 | 520 | 66.96 | 3.16 | 3.09 | 3.92 | 0.96 |
| May 19 | 280 | 66.01 | 3.36 | 3.21 | 3.91 | 1.34 |
| May 20 | 460 | 66.66 | 3.37 | 2.09 | 5.09 | 1.73 |
| Average | ... | 66.54 | 3.29 | 2.79 | 3.97 | 1.34 |

Machine B

| Date | Weight in grams of samples taken for analysis | Moisture, per cent. | Ash, per cent. | Fat, per cent. | Casein on moist sample | Casein on dry sample |
|---|---|---|---|---|---|---|
| May 17 | 540 | 69.32 | 2.33 | 3.75 | 6.01 | 1.84 |
| May 19 | 410 | 67.90 | 2.57 | 2.93 | 5.30 | 1.70 |
| May 21 | 440 | 68.25 | 2.39 | 2.59 | 7.33 | 2.30 |
| Average | ... | 68.59 | 2.43 | 3.09 | 1.21 | 1.94 |

to produce clean milk. That clarifiers are useful seems evident from their wide adoption. Through the courtesy of the Boston Biochemical Laboratory there are presented in Table 76 data showing the effect of clarification of milk as exemplified by two different makes of clarifiers and in Table 77 analyses of clarifier slime.

Bahlman showed by analysis that clarifier slime was 60 per cent. moisture and 40 per cent. solid matter and that it carried 950,000,000 bacteria per gram. The dried slime was 83.36 per cent. organic and 14.64 per cent. mineral matter. Dried powdered slime contained the constituents shown in Table 78.

Table 78.—Chemical Analysis of Clarifier Slime (Bahlman)

| | | |
|---|---|---|
| Protein ($N \times 6.38$) | 67.9 | largely casein. |
| Fat | 3.4 | partly derived from epithelial cells and other organic detritus. |
| Milk sugar | 7.8 | normal milk constituent. |
| Crude fiber | 2.2 | |
| Silica | 3.8 | derived from earth contamination. |
| Oxide of iron | 0.5 | derived from earth contamination. |
| Oxide of aluminum | 0.6 | derived from earth contamination. |
| Calcium phosphate | 3.6 | a normal milk constituent. |
| Potassium phosphate | 6.2 | a normal milk constituent. |
| Sodium and potassium chlorides | 0.1 | a normal milk constituent. |
| | 96.1 | |
| Undetermined | 3.9 | accounted for by protein factor used, and by the $SiO_2$ and $Fe_2O_3$ existing in the slime as hydrates. |

It therefore appears that the residue consists very largely of normal milk constituents. The amount of material removed of course varies in different milks. Bahlman found that in one run, in which 725 gal. of milk passed through the machine, 2.5 lb. of slime were deposited which is 1.6 grams of moist slime to the gallon. He concluded that though large numbers of bacteria were contained in the slime, the percentage removal probably was not great, since the milk is exposed to the separating action for only a brief period.

He found that by recentrifuging clarified milk in the laboratory for a longer time and at a lower speed, more sediment was thrown out thus showing that the clarifiers do not remove all the matter that it is possible to, by centrifugal force.

Hinkelman by passing a gallon of milk on the verge of souring, repeatedly through the clarifier was able materially to reduce its bacterial count and delay its souring several hours. It is his belief that bacteria of different species are of different weights and therefore that some species, being heavier than others, in the process of clarification separate out more completely. From experiments he has made he concludes that strepto-

cocci, staphylococci, pneumococci, diphtheria and typhoid bacilli, because of their greater weight, are more easily thrown out by centrifugal action than are colon bacilli and other forms that occur in milk.

Instead of using bouillon cultures, as Hinkelmann did, to study the action of milk clarifiers in throwing out disease germs, McClintock used milk cultures, with the results shown in Table 79.

TABLE 79.—ACTION OF MILK CLARIFIERS IN THROWING OUT DISEASE GERMS (McCLINTOCK)

| | Bacteria | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *B. diphtheriæ* | | | *B. typhosus* | | | *B. coli* | | |
| Number per c.c. before clarification of milk | 400,000 | 1,521,000 | 2,520,000 | 595,000 | 460,000 | 756,000 | 946,000 | 3,960,000 | 890,000 |
| Number per c.c. after clarification of milk | 17,000 | 61,000 | 75,000 | 11,900 | 5,000 | 3,000 | 5,800 | 18,000 | 17,800 |
| Percentage reduction by clarification | 95.8 | 96.0 | 97.1 | 97.9 | 99.0 | 99.7 | 99.4 | 99.6 | 98.0 |

| | Bacteria | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *B. subtilis* | | | | *St. pyogenes* | | | Common lactic bacteria | | |
| Number per c.c. before clarification of milk | 7,280,000 | 920,000 | 641,000 | 7,280,000 | 920,000 | 641,000 | 290,000 | 460,000 | 80,000 | 7,381,000 |
| Number per c.c. after clarification of milk | 70,000 | None | 6,000 | 7,000 | None | 9,300 | 260,000 | 390,000 | 70,000 | 6,200,000 |
| Percentage reduction by clarification | 99.9 | 100.0 | 99.1 | 99.1 | 100.0 | 99.0 | 10.4 | 15.3 | 12.5 | 16.1 |

The percentage reduction of pathogenic forms including *B. coli* and *B. subtilis* is remarkable, whereas the percentage reduction of the lactic bacteria is comparatively slight. Thus it would appear that milk clarifiers have a selective action in removing disease germs from milk. In confirmation of this, McClintock made further tests using mixture of disease germs and lactic bacteria in milk and found that 95.8 to 99 per cent. of the disease germs and only 15.3 to 16.1 per cent. of the lactic bacteria were thrown out.

Further observations will be necessary before definite conclusions as to the practical value of this action of clarifiers can be reached but it seems that it must be helpful although it is hardly probable that reliance can be placed on clarifiers to wholly remove disease germs.

**Standardizing.**—From the mixing vats the milk goes to the standardizing vats where it is brought to the butterfat content that the contractor has determined the milk he sells shall have. Practically, this is generally fixed by the minimum requirement of the milk ordinance of the city for butterfat. Thus if the code establishes 3.2 per cent. as the minimum butterfat content of whole milk, most dealers will sell milk that tests 3.3 to 3.5 per cent., whereas if 3.5 per cent. is the standard, milk that runs a trifle higher in butterfat will be sold. Since the milk standards of most communities are set so low that the milk of all but a few cows can meet them, much of the milk delivered at the milk plant carries more butterfat than the law stipulates as necessary, and standardization of such milk means lowering the butterfat content in some way. On the other hand, some milk that is low in butterfat in standardizing has the content thereof raised. When the milk of a herd runs close to the set limit a little richer milk or cream is often added to bring the herd milk above suspicion. Also, a man whose herd tests but 3.5 per cent. may wish to market 4 per cent. milk and does so by skimming part of the milk he produces and adding enough cream to raise the test to the desired point while the skim-milk is used by feeding it to his stock. The laws of some communities forbid standardization on the ground that it upsets the natural ratio between the butterfat and the other constituents of the milk and also on the ground that the cream and the milk which are added are apt to be older than the milk that is to be standardized and hence are likely to increase the acidity and the bacterial count. To the first of these objections it may be replied that the ratio of butterfat to total solids varies considerably in the different breeds of cattle and that there is no evidence that the changing of the ratio by standardization is in any way disturbing to the health of the great bulk of milk consumers. The truth of the other allegation must be admitted but it is for the interest of the dealer to use fresh milk and cream in standardizing for, if he does not, the keeping quality and the flavor of his milk is likely to be impaired so that the danger to be apprehended from this source is less grave than might be expected. As a matter of fact the public is probably served with a more uniform quality of milk where standardization is practised than where it is not. So the wisdom of laws prohibiting standardizing may be doubted especially as they do not appear to be particularly beneficial and certainly invite evasion and encourage deception, because dairymen see no harm in the practice, and are neither going to run the risk of prosecution for selling milk that, although it normally is a trifle above what the law requires in butterfat, occasionally falls below it, nor stand

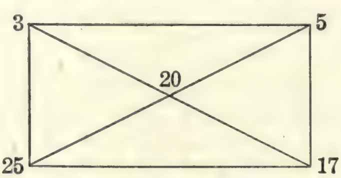
the financial loss which would ensue from selling milk from a high-testing herd in competition with that of the low-testing herd of a rival. Detection of the violation of such laws is not easy and their enforcement is difficult. Perhaps it might be required to mark this standardized milk as "blended." In some cities condensed milk is used in standardizing; the author would regard this as an adulteration. It is said that milk powder is extensively used for mixing up a milk to be used in blending and that it is very difficult to detect this practice.

In Copenhagen the richness of the milk is plainly marked on the containers and the price of milk is based on the butterfat content. In the United States this policy has not been adopted; it seems honest for it allows the consumer to pay for what he wants and can afford. Some time it may be adopted here but it is easy to foresee that the prejudice of custom will have to be overcome and that the delivery of milk of several different grades from one wagon presents difficulties.

Hinman has pointed out that this tendency of the large milk contractors to supply milk of uniform butterfat content tends to eliminate the effect of the seasonal changes of the milk. Normally in the spring when the cows go from grain feeds to pasturage there is a drop in the butterfat content of the milk which is followed by a rise to a point somewhat above the summer average and that rise is succeeded by a drop to midsummer level after which there comes another rise to the high butterfat content of winter and concentrated feeds. Analysis of the milk sold in Indianapolis shows that in contrast to this condition which obtained from 1906 to 1910, the butterfat from 1911 to 1913 remained practically uniform throughout the year.

In practice, milk is standardized by either increasing or decreasing the percentage of butterfat in normal milk. It may be increased by adding cream or a richer milk, or by skimming a portion of the milk and returning the cream obtained to the rest. The butterfat content of milk may be decreased without watering the milk, by adding milk poorer in butterfat, or skim-milk or by skimming part of the normal milk and adding the skim-milk to the remainder.

Pearson of the Cornell University Agricultural Experiment Station suggested the use of the following diagram, a rectangle with two diagonals, in solving problems in standardizing. The tests of the milk or




creams to be blended are written in the left-hand corners and the desired test in the center, while in the right-hand corners are placed figures that

represent the difference between the test diagonally opposite, and the desired test in the center. Then the figure in the upper right-hand corner indicates the required amount of milk or cream of the test of that in the upper left-hand corner, and the figure in the lower right-hand corner the amount required, of the test in the lower left-hand corner.

*Problem.*—In what proportion should a 3 per cent. milk be mixed with a 25 per cent. cream to get a 20 per cent. cream and how many pounds of each would be necessary to make 75 lb. of the light cream?

Five, the difference between 20 and 25, and 17, the difference between 3 and 20, indicate respectively the number of parts of 3 per cent. milk and the number of parts of 25 per cent. cream that should be used in blending the 20 per cent. cream. Having determined this proportion, the quantities of each required to make up 75 lb. of the light cream is calculated as follows:

$\frac{5}{22} \times 75 = 17.04$ lb. of 3 per cent. milk.
$\frac{17}{22} \times 75 = 57.96$ lb. of 25 per cent. cream
$17.04 + 57.96 = 75$

Various manuals on milk testing show how other problems can be solved in a similar manner.

**Storage in Tanks.**—After standardization, the milk is ready for pasteurization or, if that process is omitted, for canning or bottling but if the milk is not used at once it is stored in large brine-jacketed tanks where it is held at a temperature sometimes as low as 35°F. until needed. The amount of milk thus held for use is sometimes very great; in one of the Philadelphia milk plants there are four steel glass-lined tanks each of which has a capacity of 20,000 gal.

**Preservation of Food by Heat.**—From primeval times, mankind has applied heat to food in order to make it palatable, digestible and safe, but for only the past century and a half has he heated it with the definite object of preserving it. Spallanzani in 1765 boiled meat extract for an hour in hermetically sealed flasks and observed that thereafter no disintegration of the extract occurred. In 1782 Scheele advised that this principle be applied to the preservation of vinegar by exposing it in bottles to the temperature of boiling water. In 1804 Appert of Paris discovered the process of canning and in 1811 published a treatise on "The Art of Preserving Animal and Vegetable Substances." Durand, in England in 1810, took out a patent for preserving certain foods in tins and glass jars. In 1819–20 the pioneer canners of America, Daggett, Kensett, Underwood and Mitchell made the small beginnings of what has since developed into the canning industry. All of these men worked empirically because the preservation of food by heat, depends on bacteriological principles that were not understood till the researches which Louis Pasteur carried on from 1860 to 1864, on the "diseases of wine" were

completed. He found that by heating wine to temperatures ranging from 122 to 140°F. souring and other undesirable changes could be prevented. The process has proved applicable to a variety of foods and has been called in honor of the discoverer, pasteurization. It may be defined as the process of checking or delaying bacterial decomposition of food and other substances, by exposing them to heat in such a manner as to effect a partial destruction of the contained germs, leaving alive only those that are in the spore state and others that, though they survive, bring about changes in the substance but slowly or not at all. Pasteurized foods will not keep indefinitely for usually some germs in time attack them. Pasteurization is to be carefully distinguished from sterilization by heat, for in the latter process such high temperatures are used that both the germs and their spores are killed. Sterilization as a means of preserving foods is severely limited, for the temperatures used to effect it are so high that many foods are injured to such a degree as to be unusable.

**Application of Pasteurization to Milk.**—The attempt was made to sterilize milk for human consumption but it was found necessary to heat it for a long time at 212°F., or to higher temperature which gave the milk a decided flavor, caramelized the milk sugar and otherwise radically changed it so that the public would have none of it. Pasteurization has proved applicable to milk and from being used only by physicians in a limited way and for special purposes has been accepted by the public and is practised commercially on a tremendous scale.

Soxhlet in 1886 was the first to propose the use of heated milk in infant feeding. In this country the first allusion to the subject, according to Rosenau, was in 1889 by Jacobi who had long used heated milk in his extensive practice as a pediatrician. The growth of the use of pasteurized milk was gradual for practitioners raised objections to it and the public was suspicious of it but it has overcome prejudice and established itself.

Progress in the art of heating milk also was slow, for many difficulties were encountered but they have been surmounted. Three principal methods of pasteurization have been perfected, namely: (1) the flash, instantaneous or continuous; (2) the holder, holding, held or discontinuous; and (3) in the bottle or in final-package, processes. In the flash method milk is exposed for from a few seconds to perhaps 3 min. at temperatures of from 175° to 185°F., while in the holder method temperatures of from 140° to 150°F. are used and the exposure is usually for 20 to 45 min. The bottle or final-package method may be regarded as a modification of the holder process and the temperatures and times of heating are about the same. The bottling of milk hot which has been proposed by Ayres and Johnson amounts to a variation of the bottle method and is in the experimental stage.

The dairy industry has adopted pasteurization in the manufacture of

butter and for city milk. The attempt has been made to utilize it in cheese making but so far with only limited success.

The Danes were the first to apply pasteurization in butter making. Acting on Storch's discovery in 1890, that the flavor of butter could be changed and consequently controlled by the addition of different kinds of bacteria to ripening cream, they adopted the use of starters in butter making. The starter is prepared with certain precautions by growing a known mixture of bacteria in milk that has been heated nearly to boiling and when ready is used to inoculate the cream which is either obtained from pasteurized milk or is itself pasteurized. The Danes used the flash process of pasteurization and adopted 185°F. as the legal minimum because the studies of Bang in 1894 showed that the *B. tuberculosis* is killed at that temperature and because he persuaded them to protect their young stock from this and other diseases by enacting a law in 1898, requiring that all skim-milk should be pasteurized before being returned to the farm. The Danes were so very successful in the London and other markets, with their butter made from pasteurized cream that the process of manfacture was gradually adopted by others and now in the United States and elsewhere many buttermakers are using it.

Various difficulties that arise in the manufacture of cheese are of bacterial origin so that it would seem that the pasteurization of the milk which is used might be helpful but it has not proved so because of two difficulties that are encountered, to wit: that heated milk coagulates slowly with rennet, giving a loose spongy curd that is too fragile to be handled successfully; and second, it produces a curd that expels whey slowly. As the result of experiments conducted from 1905 to 1911, Sammis and Bruhn have brought out a process of cheese manufacture wherein the milk is pasteurized by the flash process at 160 to 165°F., and is afterward acidified with hydrochloric acid which restores its coagulability with rennet and brings the acidity to a point where the whey is rapidly expelled by the curd. Several factories have adopted the process; the Bowman Dairy Co. of Chicago has equipped two of its milk stations with outfits to utilize the process, and during the flush run of milk in the summer of 1914, used it in making 335,000 lb. of cheese. Sammis has also devised two methods of making cheese from the buttermilk of pasteurized cream.

**The Work of Koplik.**—In this country, the introduction of pasteurization to the city milk business was gradual. Heated milk was first used by a few pediatricians. Then, in 1889 the first milk depot was opened in New York City under the direction of Dr. Henry Koplik. This institution distributed pasteurized milk and through its operations the public began to understand what pasteurized milk was, and to use it. The physicians of that day used rather higher temperatures in pasteurizing than are recommended now. Dr. Koplik pasteurized the milk he distributed at 185° to 195°F. because he found that milk so heated kept

well in a moderately cool place for 24 hr., whereas the milk pasteurized at from 150° to 160°F., since it was somewhat carelessly handled by the mothers, soured within that time.

**Work of Nathan Straus.**—Milk charities have had a powerful influence in spreading the gospel of pasteurization and in this connection the work of Nathan Straus was sound and far-reaching. He became convinced that the infant death rate could be materially reduced by bettering the milk used by the poor and he believed that this could be accomplished by supplying them pasteurized milk. Accordingly in 1893 in New York City he established his first milk depot. From the beginning and ever afterward the work was carried on under expert medical advice. His first infants' milk depot was open from June to November and distributed 34,400 bottles of pasteurized and modified milk. The success attained was so great that Straus was encouraged to continue the experiment another year and on a larger scale; so, six stations were maintained in 1894, five of them being kept open from the middle of May to the end of the heated season and one to the end of the year so that from this time on the service was continuous. This second year, 306,446 bottles were distributed which was a ninefold increase from the previous year. Thereafter, the demand for the pasteurized milk grew steadily so that in 1906 there were 3,140,252 bottles distributed from 17 stations. In 1894, Mr. Straus undertook to disabuse the public of the idea that pasteurized milk was a medicated product, by selling it in the city parks at 1 ct. a glass and for this purpose milk was in part obtained from the plant of the Appleberg Hygienic Dairy Co. of Pauling, N. Y. In the Straus plant, milk was pasteurized by the holder process for 20 min. at 167°F. The demand often taxed the facilities of the plant severely but from the very beginning the policy was adopted of distributing no milk that had been pasteurized for more than 24 hr. The Straus Milk Charities were heartily supported by the New York City Board of Health, hospitals, charitable organizations and the *World*, which encouragement contributed to their success. Following the introduction of this pasteurized milk there was a marked decline in the infantile mortality rate of New York City, and this Mr. Straus and others believed to be due to the use of the pasteurized milk. The Board of Health of Brooklyn found the infantile death rate of that city very high and in 1894 applied to Mr. Straus for help. He furnished them with over 1,000 bottles daily and there followed a reduction in the deaths of children that was comparable with that in New York City.

As illustrative of the good results that followed the introduction of pasteurized milk, the experience at Randall's Island may be cited. The waifs picked up on the streets of New York were taken to the hospital of this institution and the death rate among them was very high although the milk was obtained from a carefully selected herd pastured on the

Island. On the introduction by Mr. Straus of a pasteurizing plant at the Institution the mortality rate dropped decidedly, although there was no other change made in diet or hygiene. The reduction in the death rate of children on the Island following the introduction of pasteurization is shown in Table 80.

TABLE 80.—CHILDREN'S DEATH RATE AT RANDALL'S ISLAND, N. Y., PRIOR TO AND SUCCEEDING THE INTRODUCTION OF PASTEURIZATION

| Year | Children treated | Number of deaths | Percentage |
|---|---|---|---|
| 1895 | 1,216 | 511 | 42.02 |
| 1896 | 1,212 | 474 | 39.11 |
| 1897 | 1,181 | 524 | 44.36 |
| Total.......... | 3,609 | 1,509 | 41.81 |
| Pasteurization begun early in 1898 | | | |
| 1898 | 1,284 | 255 | 19.80 |
| 1899 | 1,097 | 269 | 24.52 |
| 1900 | 1,084 | 300 | 27.68 |
| 1901 | 1,028 | 186 | 18.09 |
| 1902 | 820 | 181 | 22.07 |
| 1903 | 542 | 101 | 18.63 |
| 1904 | 345 | 57 | 16.52 |
| Total........... | 6,200 | 1,349 | 21.75 |

Straus' efforts to lower the infantile death rate by encouraging the use of pasteurized milk attracted the attention of physicians, sanitarians and others throughout the United States, especially as like favorable results were attained in Yonkers, Philadelphia, Pittsburgh, and Cincinnati, in all of which places he introduced pasteurized milk. In June, 1895, Straus addressed a letter to the Mayor of every city in the United States urging that the pasteurization of the milk of the poor should be an object of municipal solicitude and in March, 1897, a letter of similar tenor but setting forth his argument in more detail was sent to all Presidents of Boards of Health in the United States and Canada. Furthermore, from the inception of his work to 1912 he addressed scientific societies and other bodies both in America and Europe in advocacy of the pasteurization of milk and besides wrote magazine articles explaining the process and urging the necessity of adopting it.

**Pasteurization Adopted by Milk Contractors.**—The position of milk contractors about 1895 was becoming very difficult for the sources of milk supply had been pushed further and further away from the city so that milk was shipped from a considerable distance and took a long time to reach the city; much of the milk was uniced and was carelessly handled in

transit. The inspection of dairies was not common so that a large part of the milk was unclean to start with and much of that which was not so, was likely to be on the verge of souring when it reached the city. Moreover the large contractors were confronted with the problem of supplying summer resorts with milk shipped from their city plants. Added to this was the menace of communicable disease. Previous to 1881, it was not generally known that milk could carry infection but thereafter epidemics had with increasing frequency been traced to milk and besides it was then the general opinion of physicians that dirty milk was a potent cause of infant morbidity. It was apparent that the system of milk supply in vogue lent itself to, rather than impeded, the spread of some kinds of sickness.

Under these conditions pasteurization, whereby the milk was heated to a temperature high enough to kill most of the lactic acid bacteria and all of the disease germs, appealed forcefully to the city milk dealers. It is difficult to fix the date at which the commercial pasteurization of milk was actually begun. Apparently it was first used in New York State where certain manufacturers of condensed milk who were also in the city milk business, found that the keeping powers of milk were enhanced and no detectable flavor was imparted to it by heating it for a brief period to 167°F. which temperature was later reduced to 140°F. In Baltimore one dealer pasteurized milk for infants as early as 1893, but it was not till about 1904 that any part of the general supply was pasteurized. Pasteurizing was begun in Cincinnati in 1897, in New York in 1898, in Philadelphia in 1899, in St. Louis in 1900, in Milwaukee in 1903, in Boston and in Chicago in 1908. The prime object was to prolong the power of milk to keep. Within limits this is perfectly legitimate and commendable. We do not hesitate to keep eggs, butter, cheese and a host of other things by putting them in cold storage, nor to preserve fruits and vegetables by canning them. In fact it would be a senseless waste not to thus conserve our food supply. This is as true of milk as of any other food and can only be rationally objected to on two grounds, namely: first, that the milk is held so long that either its food value becomes impaired or that while apparently usable it has in fact become injurious; and second, that the process is used to defraud the consumer by making it possible to sell him milk so inferior that if the normal course of decomposition was not interfered with, the milk would reach him in such a state that he would not buy it.

The contractors generally adopted the flash process of pasteurization. At first high temperatures were used but it was found that the milk acquired a cooked taste. The exact temperature at which this flavor becomes perceptible to the consumer varies with the degree of heat employed, the time exposure and the acuteness of taste of the consumer but for most people is at about 158°F. It was also found that a minute's exposure at

155°F., and even less at higher temperatures adversely affects the cream line. So, despite the fact that in pasteurizing milk by this process, a temperature of 176°F. must be used to kill all disease germs, because the circulating milk is not heated equally since that in contact with the heating surfaces of the machines moves more slowly than the rest, in practice, much lower temperatures were employed. The pasteurizers were built so that the speed at which the milk passed through them could be controlled by the operator and pasteurizing was actually done at temperatures ranging between 140° and 165°F. Indeed, the tendency was toward even lower temperatures; Dr. Evans stated in 1910 that prior to the enactment of the latest law governing pasteurizing the average maximum of pasteurization in the city of Chicago was 128°F. Pasteurization of this sort at these temperatures did not protect the public from disease, and it is manifest that dealers were not greatly concerned in this phase of the subject but were employing pasteurization solely to delay the souring of their milk. It did this so effectively, that without cooling, it would keep sweet till delivered to customers, hence not a few dealers regarded pasteurizing as a means of cutting down ice bills.

Moreover pasteurization was misused in another way by contractors, in that milk sometimes received two or more pasteurizations before it reached the consumers. It was pasteurized at plants in the country and was repasteurized on its arrival in the city and some dealers gave part of the milk another pasteurization, for that which came back undelivered on the wagons was heated again and sent out to customers.

A further abuse was, that in some plants, particularly those in the smaller cities, little attention was paid to the care of the pasteurizing machines, so that they became very dirty and the milk ill-flavored and of poor keeping quality.

Finally, pasteurization was used covertly; one large firm in New York City used the flash process for 5 years before it was compelled to announce to its customers that it was selling pasteurized milk. In 1906, the New York City Board of Health forbade clandestine pasteurization and in the spring of 1910 had a law passed fixing the time and temperatures at which milk must be pasteurized. Laws of the same sort were soon passed by other cities. The temperature scales decreed by New York and Chicago are given in Tables 81 and 82.

While this commercial development of the flash process was going on the holder process was attracting the attention of scientific investigators and its use at different temperatures and for various time periods began to be advocated by them. Even after its superior merits were demonstrated and laws tending to bring about its adoption were passed it was regarded with disfavor by contractors in general and they moved with extreme slowness in altering their plants for its installation. Its first cost was greater than that of the flash process and where the latter was

Table 81.—New York City Scale of Temperatures for Pasteurizing Milk[1]

Not less than

| | |
|---|---|
| 158°F. for at least | 3 min. |
| 155°F. for at least | 5 min. |
| 152°F. for at least | 10 min. |
| 148°F. for at least | 15 min. |
| 145°F. for at least | 18 min. |
| 140°F. for at least | 20 min. |

[1] At the present time no milk is considered pasteurized within the meaning of the New York City law unless it has been heated to from 142° to 145°F. for not less than 30 min.

Table 82.—Chicago Scale of Temperatures for Pasteurizing Milk

A uniform heating of

165°F. maintained for 1 min.
160°F. maintained for 1½ min.
155°F. maintained for 5 min.
158°F. maintained for 15 min.
140°F. maintained for 20 min.

already in operation the substitution of the former necessitated considerable expenditure and the longer time required to pasteurize the milk was a further objection to it in the eyes of the dealer. So it began to be felt that the contractors were opposing a necessary reform.

For all of these reasons the practice of pasteurization on a commercial scale fell into disrepute with the public. Much blame therefor may with justice be placed on the contractors but it should be remembered that it was a period of experimentation and that these men had the faith to put large sums of money in the process at a time when scientific and popular opinion was very sceptical as to the value and even the possibility of efficiently pasteurizing any large part of the milk supply. In all probability the fact that milk dealers persisted in espousing pasteurization, forced scientific investigation of its merits and in a sense compelled the development of a process that could be officially sanctioned.

**Arguments For and Against Pasteurization.**—At this point it is well to consider the arguments that are advanced for and against pasteurization; they have been widely discussed and have been met with experiments that were designed to support or disprove them.

At the start it may be noted that the mere fact that milk has been pasteurized does not make it better than raw milk; no new quality is imparted to the milk and there is no harmful quality in the milk itself to be removed. There are however five excellent reasons for pasteurizing milk.

**Pasteurization Prevents the Spread of Contagion by Infected Milk.**—The first and most important of them all is that it saves the lives of men and of animals. To protect the former appeals to us principally from the selfish and humanitarian viewpoints but it also has its economic aspect.

We do not want to contract typhoid, diphtheria, septic sore throat or other epidemic diseases ourselves through the use of milk, nor do we want others to. The cost of controlling outbreaks of epidemic disease, and the financial loss resulting from the destruction of human life and to business when such epidemics do occur, dispose the tax payers to regard with favor the use of such a simple means as pasteurization, to minimize the dangers from communicable diseases.

Likewise, the stock owner is slowly learning that he cannot afford to take the risk of bringing back to his farm from the creamery and cheese factory skim-milk and whey that are likely to contain the germs of tuberculosis and contagious abortion or possibly the virus of foot-and-mouth disease or that may even be infected with germs of human disease which may bring some member of his family low.

**Pasteurization Lowers the Infantile Morbidity Rate.**—Second, pasteurization by reducing the number of germs in milk lowers the infantile morbidity and mortality rates. It seems to be true that the intestines of small children are tender and unable to cope with large numbers of bacteria so that, as a result of drinking milk of high bacterial content, babies are prone, especially in hot weather, to develop diarrheal disorders that are often fatal.

**Pasteurization Checks Bacterial Changes in Milk.**—Third, pasteurization checks bacterial changes in milk that may result in the formation of toxins and other products of bacterial decomposition that have not been isolated but which nevertheless are believed to exist and to be harmful.

**Pasteurization Delays the Souring of Milk.**—Fourth, by partially destroying the lactic acid bacteria and other germs the keeping quality of milk is improved—a result desired by both the vender and purchaser of milk.

**Uninspected Milk Should be Pasteurized.**—Fifth, under present conditions much uninspected and even dirty milk is bound to be sold, and it is better that the public be afforded the protection that pasteurization gives than that it hazard all the dangers that such raw milk may conceal.

**Heating Milk Unnatural.**—The objections that have been made to pasteurization are many; some of them were so grave as to raise serious doubts as to whether the process could be unreservedly commended while others, though they perhaps caused some hesitation about accepting it, were not so important. In the first place, it was obvious that the heating of milk was not nature's way; young animals took milk without its being heated, therefore some questioned why man should not. In reality the comparison is not a true one for the young calf applies its mouth to the teat and so gets its milk directly from the udder without contamination from external sources, whereas the milk that man gets, is drawn into an open vessel and is usually contaminated over and over again before it is used. So man getting the milk under unnatural conditions is justified in taking

artificial means to make its acquired impurities harmless.. As man heats other foods, it is natural that he should milk. Rosenau has pointed out that milk is the only nitrogenous food that man eats raw. In fact, in many countries it is customary to cook milk but in the United States it was not, so that this new product, heated milk, was viewed with suspicion and had to make its way slowly.

**Pasteurizing Milk and Dirty Dairying.**—Another objection that was raised to pasteurization was that it would militate against sanitary dairying. It was known that much of the milk came into the cities from very dirty dairies and it was felt that pasteurization would tend to perpetuate their existence by making the milk from them more readily marketable, for in the raw state it might be expected to spoil quickly on account of the heavy contamination that it had received, whereas by pasteurization this might be delayed till the contractor could place it in the home of the consumer. It was felt, too, that pasteurization would encourage the use of unclean methods by the producer for, knowing that the milk was to be pasteurized, he would feel that the effects of his carelessness would be obliterated.

**Spore-bearing Organisms Survive Pasteurization.**—The experiments of Flügge in 1894 greatly influenced many adversely toward pasteurized milk. He heated milk to near the boiling point till few if any other bacteria than spore formers survived and then by employing suitable methods isolated 12 cultures of bacteria that when grown in milk at 98°F. for 2 days, peptonized it. Of these 12 cultures, three when so grown in milk, proved poisonous when fed to dogs; the others did not. From this work, which nowadays would not be considered extensive enough to be conclusive, the inference was widely drawn that noxious spore-forming bacteria survived pasteurization and it was believed that they were particularly dangerous in that they rotted the milk without making its putrid condition apparent to the consumer. In criticism of Flügge's results it has been said that he grew the organisms at temperatures which assured a maximum of toxin production and that according to his own account his cultures were in a stinking condition when fed to the dogs. Careful experimentation has demonstrated that at the temperatures now employed in this country in pasteurization, enough lactic acid bacteria survive to overgrow any peptonizing forms that may be present and so to prevent putrefaction taking place.

In an investigation covering 18 months extending from the spring of 1913 to the fall of 1914, Ford and Pryor studied the market milk of Baltimore and Washington in an attempt to repeat Flügge's experiments. Flügge held that milk heated to various temperatures shows after incubation, at 71.6°F. or at 98.6°F. two sorts of decomposition the one being explosive and due to gas-producing anaerobes and the other consisting of a slow liquefaction of the proteins of the milk, due to peptonizing

aerobes. The latter group of organisms seemed to him particularly significant, for the changes produced took place slowly and even though the milk teemed with microbes, its abnormal condition might be overlooked. The growth of the spore bearers would ordinarily be restrained by the lactic acid bacteria; so only in milk heated enough to destroy these lactic organisms, would the spore bearers develop sufficiently to either change the character of the milk or to endanger the health of children who might drink it. Flügge believed that the spores of the peptonizing bacteria would resist the action of the gastric juice and finding proper conditions for development in the lower bowel would multiply there and give rise to the grave symptoms of intoxication seen in summer complaint. The several organisms isolated from heated milk by Flügge were later studied by Gotschlich and Kaensche who found the principal anaerobe to be the *B. butyricus* of Hueppe and the principal aerobes, *B. subtilis, B. mesentericus vulgatus* and *B. mesentericus fusus.*

Ford and Pryor examined milk of 21 dairies in Baltimore which represented nearly every sort of milk sold in the city and Ford continuing the studies examined 24 specimens of raw milk from 17 different dairies and 27 specimens from eight sources of the commercially pasteurized milk of Washington. The results in the two cities were essentially the same. The investigators heated the milk to different temperatures, viz., 140°, 149°, 176°, 185°, 212°F. and under 20 lb. pressure for from 5 to 35 min. according to the experiment, and incubated the heated or pasteurized milk both aerobically and anaerobically at 71.6° and 98.6°F. for 48 to 96 hr. The condition of the incubated sample was recorded and agar plates poured from it. The presence of *B. welchii* was tested for by injecting the incubated sample into the ear vein of a rabbit. The conclusions arrived at were:

1. As first pointed out by Flügge, milk always contains heat resistant spores of aerobic and anaerobic bacteria which by their development can give rise to disagreeable and unwholesome changes in milk, converting it from a food of great nutritive value into an undesirable, if not a dangerous, article of diet.

2. These changes take place in milk heated to any temperature from 149° to 212°F. and kept at any temperature from 71.6° to 98.6°F., but not at that of the ice box at 39.2° to 42.8°F.

3. Spores of these bacteria survive for a long time in milk kept on ice and when such milk is transferred to higher temperatures they can initiate their characteristic changes in it.

4. The problem of pasteurization must be worked out on the basis of changes that occur in milk heated 140° to 149°F.

5. The most important anaerobic species is *B. welchii* which is believed to be universally present. Aerobic spore-bearing bacteria are also found in practically all samples and belong in general to the group

of gelatin liquefiers. Such species do not develop in raw milk nor in Washington pasteurized milk—pasteurized at 140 to 149°F. for 30 to 35 min.—only the ordinary lactic acid bacteria being found.

6. How far these spore-bearing organisms play a rôle in the clinical condition, especially that of children, is yet to be proved.

In continuation of the Baltimore work Lawrence and Ford from 1913 to 1916 worked out the cultural reactions of 250 spore-bearing bacteria isolated from 68 samples of milk, 12 of raw milk, 12 of milk pasteurized at 140°F., 32 of milk heated to 185°F. and 12 of boiled milk. They believe the cultures give an accurate idea of the spore-bearing bacteria of the milk of Baltimore and probably of that elsewhere. By their combined development in heated milk, these organisms give rise to the putrid decomposition so often observed; in the majority of instances they are energetic protein-splitters and in practically every case dissolve the protein in milk, either before or after a preliminary coagulation.

After establishing the various types of organisms by the study of 250 cultures from the 68 samples, another series of milks, also subjected to various treatments, was investigated with the object of testing the preliminary classification adopted. The types were abundantly confirmed but no new organisms were isolated which indicates that the organisms represent the spore bearers usually present in Baltimore milk. In the original 250 cultures the various species were found in the following proportions:

| | |
|---|---|
| *B. cereus*—Frankland | 124 |
| *B. subtilis* (Ehrenberg)—Cohn | 79 |
| *B. albolactus*—Migula | 25 |
| *B. vulgatus* (Flügge)—Trevisan | 15 |
| (*B. mesentericus vulgatus*—Flügge) | |
| *B. mesentericus* (Flügge)—Migula | 2 |
| (*B. mesentericus fuscus*—(Flügge) | |
| *B. fusifomis*—Gottheil | 2 |
| *B. petasites*—Gottheil | 1 |
| *B. cohaerens*—Gottheil | 1 |
| *B. terminalis*—Migula | 1 |

Besides, the following spore-bearing species were isolated from other sources which, partly from the work of others and partly because they are not infrequent in milk products, the authors believe may occur in milk:

*B. mycoides*—Flügge.
*B. megatherium*—De Barry.
*B. simplex*—Gottheil.
*B. aterrimus*—Lehman and Newmann (*B. mesentericus niger*—Lunt).
*B. niger*—Migula (*B. lactis niger* Gorini).
*B. globigii*—Migula (*B. mesentericus ruber*—Globig).

Shippen investigated the growth of *B. welchii* in milk. He found that when it is transferred to that medium with the common aerobic

spore bearers or with *B. troilii* it assumes the power of growth under aerobic conditions and its reactions overwhelm those of the bacteria with which it grows. When the organisms are heated to 140°F. *St. lacticus* inhibits the reactions produced by *B. welchii* upon milk in the presence of *B. troilii* and the aerobic spore bearers, unless these spore bearers are present in vast numbers, when it fails to do so, as it does when no heat is applied. The reactions observed in milk heated at temperatures ranging from 140° to 185°F. may be simulated in the presence of *B. welchii* by the growth of the aerobes commonly surviving the temperatures considered after the application of the desired degree of heat.

H. R. Brown made a study of the anaerobic bacteria in the market milk of Boston, and the results of his studies appear in the reports of the Massachusetts State Board of Health.

Since Flügge's time painstaking investigations have been made to determine the bacteria that survive pasteurization. Inquiry has been focussed on the lactic bacteria, the coli, the streptococci and the spore formers.

**Other Bacteria that Survive Pasteurization.**—Ayres and Johnson working under laboratory conditions that precluded recontamination of the milk, studied the bacteria that survive pasteurization by the holder process at several temperatures. They classify the bacteria in raw milk in four groups, namely: (1) the acid; (2) the inert; (3) the alkali; and (4) the peptonizing groups. The acid group is divided into two subgroups, to wit: (*a*) the acid-coagulating, which coagulates milk in less than 14 days; and (*b*) the acid group which produces acid but does not coagulate milk in 14 days. In raw milk the inert group is the largest. In milk pasteurized 30 min. at 145°F. there is plainly a great increase in the proportion of the acid and acid-coagulating subgroups while the alkali and peptonizing groups form smaller percentages of the whole. At 160°F. the acid group is still the largest but the acid-coagulating subgroup is composed of bacteria that coagulate very slowly. At this temperature the alkali group is greatly reduced and the peptonizing group is reduced to the minimum. At 170°F., the acid group remains about the same, but the organisms produce acid and coagulation very slowly. The alkali group is practically destroyed, though an occasional sample may show this group in fairly high percentage. The most important change at this temperature is in the peptonizing group which, relative to the total bacteria, begins to show a percentage increase. At 180°F., this increase of the peptonizing group is very striking for no less than 75 per cent. of the surviving bacteria are peptonizers. At this temperature none of the acid-coagulating subgroup and only a small percentage of the acid subgroup are found. At 190°F. and 200°F., the bacterial groups survive in about the same relative proportion as they do at 180°F. From these

experiments it is manifest that 170°F. is a critical temperature in pasteurizing, for in milk pasteurized above this temperature there is a tendency for the peptonizing bacteria to predominate. Ayres concludes that when the bacterial flora of pasteurized milk is under discussion the temperature of the process is of fundamental importance and he cautions that these summaries represent average conditions and are subject to exceptions.

**Ability of B. coli to Survive Pasteurization.**—Certain boards of health have taken the presence of more than a few colon bacteria in pasteurized milk as evidence that the pasteurization has not been efficient or that subsequent thereto the milk has been contaminated. The attempt to establish this criterion for pasteurized milk evoked a storm of protest and led to investigations of the ability of *B. coli* to survive pasteurization. Ayres and Johnson conducted a series of experiments to determine the question and reached the following conclusions:

"1. The thermal death point of 174 cultures of colon bacilli isolated from cow feces, milk and cream, human feces, flies and cheese, showed considerable variation when the cultures were heated in milk for 30 min. under pasteurizing conditions.

"At 140°F., the lowest pasteurizing temperature, 95 cultures, or 54.59 per cent., survived; at 145°F., the usual pasteurizing temperature 12, or 6.89 per cent., survived.

"One culture was not destroyed at 150°F. on the first heating, but thereafter, in repeated experiments, always was.

"2. There is a marked difference in the effect of heating at 140°F. Although there is a difference of but 5°, 87.3 per cent. of the cultures which survived at 140°F. were destroyed at 145°F.

"3. Considerable variation was found in the thermal death point of the colon bacilli that survived 145°F. When the 12 cultures that survived were heated again at the same temperature, many did not survive and different results were obtained at each repeated heating.

"145°F. for 20 min. seems a critical temperature for colon bacilli.

"4. All of the 174 cultures studied had a low majority thermal death point but were able to survive pasteurizing temperatures on account of the survival of a few cells.

"5. The colon test as an index of the efficiency of pasteurization is complicated by the ability of certain strains to survive a temperature of 145°F. for 30 min. and to develop rapidly when the pasteurized milk is held under temperature conditions that might be met during storage and delivery.

"The presence of a large number of colon bacilli immediately after the heating process may indicate improper treatment of the milk.

"6. If milk is pasteurized at 150°F. or above for 30 min., the results indicate that no colon bacilli would survive. Under such conditions the colon test may be of value in determining the efficiency of pasteurization. However, further research may discover strains of colon bacilli that will survive this temperature and even higher ones."

**Ability of the Streptococci to Survive Pasteurization.**—Because the Smith Streptococcus often is conveyed from man to the udder of the cow and causes milk-borne outbreaks of septic sore throat and because garget, a common affection of the cow's udder, is often caused by streptococci, the ability of streptococci to withstand pasteurization excited interest. The question was investigated by Ayres and Johnson. They found that the thermal death point of 139 cultures of streptococci isolated from cow's feces, from the udder, from the mouth of the cow and from milk and cream showed a wide variation when the organisms were treated for 30 min. under pasteurizing conditions.

At 140°F., the lowest pasteurizing temperature, 89 cultures, or 64.03 per cent., survived; at 145°F., the usual pasteurizing temperature, 46 cultures, or 33.07 per cent.; at 160°F., 2.58 per cent.; and at 165°F. all were killed.

On the whole, streptococci from the udder were less resistant and those from the milk and cream were more so than those from the mouth of the cow and from cow's feces.

At 140°F. all of the 18 cultures from the milk and cream survived; at 145°F. 17, or 94.94 per cent., and at 155°F., nine cultures, or 50 per cent., withstood the heating; all of the cultures died on exposure to 165°F. for 20 min.

Among the 139 cultures of streptococci there were 22 that formed long chains and that were considered typical streptococci; the rest were held to be atypical. Of the typical streptococci 12, or 54.54 per cent., survived heating at 135°F. for 30 min., 9, or 40.91 per cent., survived at 140°F., and a single culture, or 4.54 per cent., withstood heating at 145°F. At 150°F. for 30 min. all of the typical streptococci were destroyed.

The 117 atypical streptococci were more resistant. At 140°F., 68.37 per cent. survived; at 145°F., 38.46 per cent.; at 160°F., 2.56 per cent.; while at 165°F. all were destroyed.

The authors conclude that two classes of streptococci survive pasteurization, viz.: (1) Streptococci that have a low majority thermal death point but among which a few cells are able to survive the pasteurizing temperature. This ability of a few streptococci to survive the pasteurizing temperature may be due either to certain resisting characteristics peculiar to a few cells or to some protective influence of the milk. (2) Streptococci having a high majority thermal death point. These survive because the majority thermal death point is above the pasteurizing temperature. This ability to withstand heating is a permanent characteristic of certain strains of streptococci. These experiments are comparable to commercial pasteurization by the holder process but had more cultures been examined other results possibly might have been obtained.

**Effect of Pasteurization on Mould Spores.**—The effect of pasteurization on mould spores has recently been studied by Thom and Ayres. The

spores of moulds are certainly present and are often abundant in market milk. Studies were made with pure cultures of a series of moulds including several species of Aspergillus and of the mucors with the addition in some experiments of *Oidium* (*oöspora*) *lactis* and one strain of Fusarium. Experiments were made to test the effect of temperature in the holder, and in the flash processes of pasteurization, and by dry heat. The results agree in general with the bacteriological studies of pasteurization.

Very few of the spores survived heating in milk to 145°F. for 30 min. Certain moulds, notably *Aspergillus fumigatus* and *A. flavus*, do survive but they occur only rarely in milk. *Oidium lactis* and the mucors which are probably more important as milk-borne organisms than all the other moulds, are destroyed at this temperature and exposure. So pasteurization of milk at 145°F. may be regarded as destroying mould spores completely enough to render them a negligible quantity.

In using the flash process of pasteurization temperatures of 165°F. to 175°F. for 30 sec. are commonly employed. It was found that very few of the moulds were killed at 145°F. for 30 sec. but that nearly all were in that time at 155°F. and likewise that 30 sec. exposure at 165°F. to 175°F. destroys practically all spores as they are found in milk, although a few conidia in some species may occasionally survive. The observation that the moulds were killed at temperatures of from 165°F. to 175°F. is confirmed by the results of Webster of the Bureau of Chemistry showing that commercial butter made from flash-pasteurized cream contained no mould spores whereas cultures from commercial butter contained 20,000 to 60,000 per cubic centimeter.

**Multiplication of Bacteria in Pasteurized Milk.**—Certain investigators were of the opinion that bacteria increased more rapidly in pasteurized than in raw milk and that this constituted a serious objection to its use, for in cooling, bottling and in the subsequent handling of it, the milk was often rather heavily contaminated, but careful work by Ayres and Johnson showed this criticism to be ill-founded for when the bacterial increment in an efficiently pasteurized milk is compared with that in a clean raw milk held at the same temperature, the two are found to be about the same.

**Destruction of Toxins by Pasteurization.**—Others pointed out that pasteurization probably does not destroy toxins that may develop as the result of bacterial growth in milk. If such toxins exist they have not been isolated, therefore the temperatures at which they are destroyed are unknown. The true bacterial toxins are not destroyed by pasteurization by heating at 140°F. for 20 min. but heating milk to this temperature kills many germs and so makes the further formation of toxins in it less probable. Of course, raw milk that supports a heavy growth of germs may contain toxins and would be quite as injurious before pasteurization as afterward.

**Physical and Chemical Changes Induced in Milk by Pasteurizing.**—It is charged that pasteurizing milk changes its physical and chemical properties to its detriment. It is true that milk is altered by heating but careful investigation by many observers has established the fact that the changes that are induced depend on the degree of heat applied and on the length of the heating period. North has compiled the results reported by many students of the subject and has made a graph, Fig. 41, illustrating the most important changes that take place in the milk and the effect of heating on certain disease germs. It appears that the salts begin to be

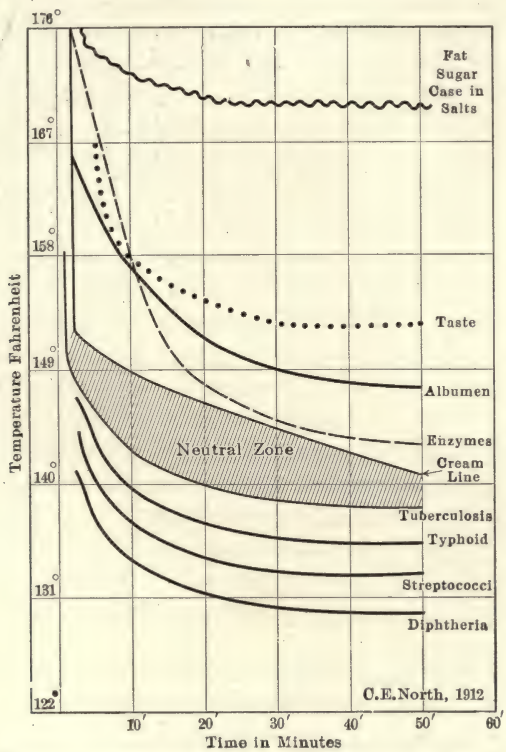



FIG. 41.—Time and temperature for milk pasteurization, C. F. North.

affected when the milk is heated to 170°F. for 40 min. and in less time as the temperature of heating rises till at 176°F., heating for 1 min. affects them. The principal changes that occur are the precipitation of calcium and magnesium salts and a great part of the phosphorus together with a decrease in organic and an increase in inorganic phosphorus. The albumin is more sensitive to heat; it is injured by heating it for 30 min. at 149°F., or for 10 min. at 158°F. and in correspondingly less time at higher temperatures.

The enzymes, the figure shows, may be heated to 149°F. for 20 min.

or to 145°F. for 30 min. without suffering injury but longer periods of heating at lower temperatures affect them harmfully. According to Kastle enzymes cannot be exposed many minutes to temperatures between 149°F. and 158°F. without weakening their activity nor to temperatures between 158°F. and 176°F. for more than a brief interval without being destroyed. Tuberculosis, typhoid fever and diphtheria germs are all killed by heating the milk for 20 min. at 140°F. or in much less time at higher temperatures. In actual practice a considerable margin of safety is taken. By the holder process the milk is commonly heated to 145°F. for 20 to 45 min. The Danes in using the flash method in their creameries heat the cream and skim-milk to 176°F. and the Chicago regulations require heating for 1 min. at 165°F. The cooked taste appears in milk if it is heated to 158°F. for 20 min. or for a less prolonged exposure at higher temperatures. The cream line is affected by heating the milk for 50 min. to 140°F. and for 1 min. at 155°F. The most important point brought out by the chart, from a practical standpoint is, that contained within the tuberculosis and the cream lines is a safety zone for heating milk, for when the intersection of a vertical minute line with a horizontal temperature line falls within the zone, milk can be heated to that point without danger of injuring it. Besides the changes delineated by North others that are brought about by heating are the rendering of the casein less readily coagulable by rennin and less easily and more slowly acted on by pepsin and pancreatin. If milk is heated in metal containers to high temperatures, the milk takes a brownish cast which is thought to be due to caramelization of the lactose as a result of a little of the milk coming into contact with the hot metal and being scorched.

It has been contended that owing to these several changes milk is made less digestible by pasteurization but the careful observations of physicians shows that this is not so with milk pasteurized at temperatures now in use.

**Suitability of Pasteurized Milk for Infant Feeding.**—Whether or not pasteurized milk is suitable for infant feeding has excited a world of discussion. It is the general belief that children fed on such milk do not contract diarrheal diseases, nevertheless its use has been condemned by many physicians on the ground that it is the cause of rickets and scurvy and by some on the ground that the enzymes are killed. With regard to the enzymes in milk it may be said that as yet it is not known to what extent they are a part of the milk itself and to what extent they are an elaboration of the bacteria of the udder. The evidence seems clear that they are not injured at the temperatures used in modern pasteurization. It cannot be said that final opinion has been reached as regards feeding very young children pasteurized milk but the tendency is to take a conservative position in the matter. On the one hand is the evidence that in Europe milk charities, under medical direction, on a large scale have used

milk pasteurized at high temperatures without undue prevalence of rickets and scurvy among the children, and the like experience of child welfare stations in this country using milk pasteurized at low temperatures. On the other, statistics are offered from hospitals and other sources to the effect that out of a considerable number of babies who developed rickets and scurvy a considerable percentage were being fed pasteurized milk prior to the onset of the disease. The studies of Hess which were made at a New York institution where the babies remained for a year or more and were weighed and measured at regular intervals, have made plain the relation between pasteurized milk and infantile scurvy. He finds the disease belongs to the same class as beriberi and others that are due to the continued use of a food that is deficient in some essential substance. Pasteurized milk is this sort of food for its antiscorbutic vitamines are partially destroyed in the pasteurizing process and so when babies are fed on such milk, unless an antiscorbutic such as orange juice is given with it, they develop a subacute type of scurvy. This is the most common form of the disorder and is easily overlooked. Babies derive antiscorbutic material from their mothers but when artificial feeding is begun this protection is lost. Since pasteurized milk still contains some vitamines it takes an infant that is fed on it without antiscorbutics, 7 or 8 months to develop scurvy from its use. During the development of the disease the growth of the baby is usually arrested. The weight stops increasing and remains stationary for weeks or months, but the child responds quickly to orange juice or its equivalent, often making supergrowth till it attains the correct weight for its age. An underfed child, if given the amount of food it needs, may respond to this impulse and increase its weight throughout the scorbutic condition. Measurements show that the growth of the infant in length is retarded during a long attack of scurvy but that on the administration of orange juice, growth begins again as vigorously as ever. Hess recommends the use of pasteurized milk in infant feeding on account of the security which it affords against infections, but he advises that when infants are fed exclusively on a diet of pasteurized milk, antiscorbutics should be given far earlier than at present, even as early as at the end of the first month of life. The question whether an infant ought or ought not to have pasteurized milk is purely a medical one and should be settled by the orders of the physician. As illustrative of the results obtained in the use of pasteurized milk in child welfare stations those obtained from April 24, 1911, to Oct. 24, 1912, at the George M. Oyster, Jr. Milk Philanthropy in Washington, D. C., are presented.

Of the babies 131, or 18.8 per cent., were born out of wedlock and were regarded as burdens by those having them in charge.

The reasons given for bottle feeding by those who brought the babies to the station were:

| | Per cent. |
|---|---|
| Mother obliged to go out to work | 25.40 |
| Mother able to supply by nursing but part of the milk necessary | 25.08 |
| Mother's milk failed | 15.40 |
| Mother too ill to nurse | 9.16 |
| Mother dead | 7.50 |
| Mother's milk not nourishing | 7.50 |
| Mother deserted the baby | 5.80 |
| Mother never able to nurse | 4.16 |

In the entire period 20 physicians and two to four graduate nurses coöperated in the work. The nurses gave their entire time and, besides being present and helping in the examination of babies at the stations, visited the homes of the children.

In all 1,128 babies were prescribed for and 377,500 bottles of milk distributed. The records of 110 babies were not complete. Of the 1,108 others it was found:

| | |
|---|---|
| 557 babies prescribed pasteurized milk exclusively showed an average net gain of | 0.4077 oz. per baby per day. |
| 351 babies prescribed raw milk exclusively showed an average net gain of | 0.4030 oz. per baby per day. |
| Difference in favor of pasteurized milk | 0.0047 oz. per baby per day. |

110 babies prescribed both pasteurized and raw milk at different times showed:

| | |
|---|---|
| On pasteurized milk an average net gain of | 0.4607 oz. per baby per day. |
| On raw milk an average net gain of | 0.4312 oz. per baby per day. |
| Difference in favor of pasteurized milk | 0.0295 oz. per baby per day. |

**Milk for Babies a Special Milk.**—It is now recognized that in our large cities it is not feasible to bring the whole milk supply up to the standard of that required for infant feeding. The procuring of a supply of babies milk is a special problem of city milk supply and this should be remembered in relation to pasteurization. Pasteurization protects babies from diarrheal diseases, typhoid fever, diphtheria, scarlet fever, and from bovine tuberculosis and, if in the opinion of some physicians this advantage is outweighed by other considerations or at least in some cases makes the use of raw milk advisable, it does not follow that for these reasons older children and adults should surrender the protection from communicable disease that the use of pasteurized milk affords.

**Pasteurization an Additional Process.**—It has been urged that pasteurization is an additional process to those already in use in preparing milk for the market and involves exposing it to new sources of contamination and to the possibility of infection from another group of workers in the milk plants. That there was some slight grounds for these fears

must be admitted but practically they have not proved serious obstacles to the success of the process. Calloway tells that in a plant in Portland, Ore., which was pasteurizing milk by the holder method at 140°F., the milk entering the pasteurizer showed a bacterial count of 50,000 per cubic centimeter and that issuing from it 200,000. Investigation showed that the inside of the pipes were so badly corroded and pitted that the machine could not be kept clean. In a *Milk Plant Letter* of the U. S. Department of Agriculture it is stated that the pasteurizer is one of the most difficult pieces of machinery to keep clean but that it must be kept so, for if it is not, on the inside a cooked layer forms which daily grows worse. The self-interest of the contractor operates to keep down this sort of thing for it is likely to make itself known to customers in a product so inferior that they reject it. The watchful eye of an alert inspector is a good corrective to uncleanliness. Epidemics have seldom been traced to pasteurized milk and of the few that have, only a small percentage were thought to be derived from the men who were doing the pasteurizing.

**Milk Liable to Recontamination after Pasteurization.**—Except when the pasteurization is done in the bottle there is opportunity for the milk to be recontaminated in the bottling and capping. In fact before it had been ascertained that lactic acid bacteria survive pasteurization at low temperatures, several observers were inclined to attribute the souring of commercially pasteurized milk to this recontamination, and brought forth the suggestion that instead of depending on this chance method to bring about the desirable souring of pasteurized milk it would be well to assure it by inoculating the pasteurized milk with a lactic culture. This procedure was never practised. No doubt some contamination with lactic and other germs does occur after the milk is pasteurized, and this being the case it must be admitted that there is an opportunity also, for the pasteurized milk to be infected either by the men who bottle and cap it, provided any of them are sick with, or are carriers of, infectious disease, or by filling the milk into insterile infected bottles and other containers. Bottle infection of pasteurized milk was suspected to have actually occurred in Rockford, Ill., in 1913. The infection of milk subsequent to pasteurization and before delivery to the consumer is very unusual but it may occur, and both health officers and the public should know that while the chances of pasteurized milk becoming a medium for the spread of communicable disease are remote, they nevertheless exist. So long as it was believed that germs grew more rapidly in pasteurized than in raw milk, there was considerable concern over dangers that it was conceived might arise from the contamination of pasteurized milk in the home of the consumer, but anxiety on this score has dissipated.

**Overconfidence in Pasteurized Milk.**—The last objection to the use of pasteurized milk that merits notice is the contention that pasteuriza-

tion begets a sense of false security on the part of the consumer, that he comes to believe that since the milk has been pasteurized it is absolutely safe and will remain so in his hands. Exuberant advertising has perhaps had some tendency to lead the public to trust pasteurized milk too implicitly but in general the faith placed in pasteurized milk is warranted and much good results from allaying the mistrust of anxious mothers that sickness may be lurking in the milk they are feeding their children.

**Pasteurization and the Score Card.**—About 1908 the tide of criticism that had been running against pasteurization began to subside and now the process has emerged and stands well-favored. Many factors brought about the change but seven were particularly important.

1. The so-called official score card began to be widely used and to prove itself a helpful corrective of the dirty dairies and insanitary methods it was so greatly feared pasteurization would perpetuate. The score card and pasteurization work together nicely, the one impels the dairy farmer to produce milk in a clean place and in a sanitary manner and the other enhances the keeping quality of the milk so produced and reduces the chances of contracting contagion from it almost to the vanishing point.

2. **Milk Liable to Bovine Infection.**—Sanitarians finally realized that the cow is very subject to certain diseases which infect the milk with their germs. Furthermore, they found that in some of the infectious diseases of man, the ambulatory cases and bacillus carriers were more common and more potent factors in the spread of contagion than had been believed and that the operation of these infectious agents was so insidious that it was apparent that even those dairymen who were doing their utmost to protect their milk from infection would at times fail in their efforts.

The germ diseases of the cow which are so common as to have an important bearing on the pasteurization problem are tuberculosis, contagious abortion and certain forms of mammitis. As it became known how prevalent bovine tuberculosis is, in the herds of dairy districts where the chief business is supplying the city milk trade, and as it came to be understood that it would be years before the disease could be eradicated, it was seen that pasteurization would greatly minimize the danger that children ran in drinking milk. The germs of contagious abortion are common in market milk; so far as known they are not pathogenic for man but Schroeder has pointed out that on general principles it is not well for one race to be constantly exposed to germs that are pathogenic for another so that, if this view is accepted, an additional reason for pasteurizing milk for human consumption is found. Both bovine tuberculosis and contagious abortion inflict much loss on the owners of farm animals and as the germs of these diseases are found in skim-milk and whey from creameries and cheese factories these products should be pasteurized before being returned to the farm.

Septic sore throat powerfully influenced sanitarians to accept pasteur-

ization. This disease was first recognized in this country in 1911 when it was the cause of a widespread epidemic in Boston. One of the most carefully supervised dairies in New England was the victim of its onslaught. This epidemic was followed by other extensive outbreaks of the same disease in several of the principal cities of the United States. While in some instances the sanitary standards of the dairies that were attacked were not commendable, in others they were excellent and it was evident that the disease might get into a dairy without those responsible for the conduct of the business being aware of its presence, consequently they could not justly be held responsible for distributing it. When septic sore throat first began to be recognized it was very strongly suspected that the streptococci that caused it were derived from the udders of cows suffering with mammitis. As it was known that in most large herds there were usually one or more cows that had the disease, the question arose as to what extent these animals menaced the public health. At that time the evidence had not been collected that it is those cows whose udders have been infected with streptococci by persons having septic sore throat, or by carriers of the Smith streptococcus and there was serious concern over the possibility that all gargety cows might be more dangerous than had hitherto been believed. Boards of health were active and attempted to exclude from the market milk that had a high cellular content but this position was found untenable, because it was discovered that the milk of perfectly healthy cows as well as that of those suffering from mammitis, at times had a high cellular count. Then the association of long-chained streptococci with a high cell count in the milk was advanced as evidence that the milk came from a cow having mammitis and so was potentially dangerous, which sufficed to debar the milk from the market. However, this theory was not at once universally accepted so that there was neither a certain way of telling whether a given sample of market milk was in part derived from cows that had mammitis, nor for telling whether any streptococci that were observed in the milk were dangerous to man. To such a situation pasteurization offered a safe and welcome solution.

3. **Impossible to Protect Milk from Human Infection.**—The situation with regard to human disease was quite as serious as with animal diseases. For instance, Lumsden in 1908 stated that on the assumption that there were seven persons on each of the 1,000 dairy farms supplying Washington, D. C., there would be on these farms, since at that time about one person in every 300 in the United States every year had typhoid fever, 25 new cases of this one disease yearly. Bolduan states that the milk supply of New York City in 1912 came from 40,000 farms and that in one way or another 200,000 people handled the milk. The incidence of typhoid fever around New York varied from 150 to 200 cases per 100,000 annually so that these people who handled the milk would furnish 300

to 400 new typhoid fever cases every year. If it be supposed that only 2 per cent. of these became chronic carriers and that they remained such for but 15 years there would be 90 to 120 typhoid carriers continually menacing the milk supply of New York City.

The ability of pasteurization to protect a city from communicable disease is well-illustrated by the experience of Berkeley during the Richmond, Cal., outbreak of typhoid fever. Geiger and Kelly report that from a certain dairy that employs 20 men and keeps 300 cows Richmond receives 90 gal. of milk which was used by 500 people daily and Berkeley 600 gal. which was delivered to 2,000 homes where it was used by at least 6,000 people. In Richmond, where the milk was used raw, 12 cases of typhoid fever developed which led to its being promptly withdrawn from the public.

In Berkeley, where the milk was pasteurized, not a single case appeared. The milk was found to have been infected by the head milker who, a little before the source of the contagion was traced out, had been taken to a hospital where he gave a positive Widal reaction.

It is certain that even those dairymen who are most zealous in their efforts to protect their milk from infection will at times fail. Sometimes the afflicted person may begin spreading disease germs while his malady is still in the prodromal stage; the disease may not be recognized till it is well advanced or it may never be detected, besides which temporary, acute and chronic bacillus carriers may every one of them spread contagion innocently and unobserved. Indeed, to pasteurize milk is the only reliable way to prevent it from sometimes becoming the vehicle of contagion. Communities that use *raw* milk will inevitably have occasional outbreaks of milk-borne infectious disease.

4. **Pasteurization at Low Temperatures Destroys Disease Germs.**—A fourth factor in convincing people that pasteurization might be practical along right lines was the experimental, chemical and bacteriological studies of several investigators. As has been indicated previously, the chemical changes that take place in pasteurization of milk at low temperatures are quite different from those that occur at the higher ones that were in use when the pasteurization of milk was first begun. Indeed, milk is little changed by heating it for 30 to 45 min. at 145°F., a temperature and exposure that bacteriological studies have established as sufficient to kill the non-spore-bearing pathogenic organisms that occur in milk.

Up to 1899, it was thought necessary in order to kill the tubercle bacillus to either heat milk for a moment to high temperatures, as at the 175° to 185°F. advocated by Bang, or to heat it to 155°F. for 20 min. In that year Theobald Smith announced that heating milk to 140°F. for 20 min. sufficed to kill the germs, if the milk was stirred or kept covered during heating to prevent the formation of a pellicle on the sur-

face. The importance of the fact was perceived at once for heating to 155°F. for 20 min. affects the albumin, enzymes and cream line and is nearly high enough to impart a cooked flavor to milk whereas at the lower temperature trouble with these constituents and properties is avoided. Other observers, notably Hesse, Russell and Hastings, and Rosenau, confirmed Smith's findings. The thermal death points of the common disease germs have been determined by several bacteriologists. In this country the findings of Rosenau are accepted. They are published in Hygienic Laboratory *Bulletin* 42 and show that:

"The tubercle bacillus loses its virulence and infective power for guinea-pigs when heated in milk at 140°F. for 20 min., or at 149°F. for a much shorter time; in other words, it may be considered dead.

"The typhoid bacillus when heated for 2 min. at 140°F. is killed; the great majority of these organisms are killed by the time the temperature reaches 138°F. and few survive to 140°F.

"The diphtheria bacillus succumbs at comparatively low temperature; it often fails to grow after heating to 131°F.; occasionally some survive until the milk reaches 140°F.

"The cholera vibrio is usually destroyed at 131°F. and only once survived to 140°F.

"Both the Shiga and Flexner types of dysentery bacillus were experimented with. The bacillus is somewhat more resistant to heat than the typhoid bacillus but the great majority of the dysentery germs are killed by the time the milk reaches 140°F. They sometimes withstand heating to 140°F. for 5 min.; heating to this temperature for 10 min. always kills them.

"The evidence with regard to *M. melitensis* is meager. The organism is not destroyed by heating to 131°F. for a short time; the great majority of these micrococci are killed at 136.4°F. and all are killed at 140°F.

"A temperature of 140°F. for 20 min. is sufficient to destroy the virus of scarlet fever, streptococci and other pathogenic organisms.

"Milk heated to 140°F. and maintained at that temperature for 20 min. may be considered safe so far as conveying infection with any of these organisms is concerned."

These laboratory findings were tested in 1912 on a commercial scale by Schorer and Rosenau who had placed at their disposal for the purpose, a pasteurizing plant that was to be dismantled. It was equipped to handle 8,000 lb. of milk an hour by the holder process. The principal parts of the system were the receiving vat, the milk pump, the heater and the holder. Four runs were made with milk heavily seeded with cultures of diphtheria, typhoid fever, bovine and human tuberculosis. The results obtained in these experiments are briefly set forth in Table 83.

From these experiments it was concluded that by heating milk to 140°F. and holding it at that temperature for 20 min. the germs of diphtheria, typhoid fever and tuberculosis are surely killed but that probably practical conditions are best met by pasteurizing at 145°F. for 30 to 45

TABLE 83.—RESULTS OBTAINED BY SCHORER AND ROSENAU IN PASTEURIZATION EXPERIMENTS ON A COMMERCIAL SCALE WITH A PASTEURIZER OF THE HOLDER TYPE

| Run | Contained organisms | Period of holding, minutes | Temperature °F. at heater | | | Temperature °F. at holder | | | Temperature °F. after holding | | | Bacteria per cubic centimeter before pasteurizing | Bacteria per cubic centimeter after pasteurizing | Percentage of bacterial reduction | Surviving organisms |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Max. | Min. | Ave. | Max. | Min. | Ave. | Max. | Min. | Ave. | | | | |
| 1(*a*) | Diphtheria, typhoid fever, human tuberculosis....... | 20 | 159.0 | 138.0 | 150.8 | 163.4 | 123.2 | 139.6 | 149.00 | 155.6 | 141.9 | 3,600,000 | 850 | 99.9 | Human tuberculosis, cream and sediment |
| 2(*b*) | Human tuberculosis, diphtheria, typhoid fever......... | 20 | 142.0 | 135.0 | 139.1 | 143.6 | 134.6 | 139.6 | 139.96 | 128.3 | 132.6 | 8,650,000 | 1,800 | 99.9 | Diphtheria in milk, cream and sediment; human tuberculosis in cream and sediment; typhoid fever in cream and milk |
| 3(*c*) | Bovine tuberculosis. | 20 | 148.0 | 145.3 | 145.3 | 149.0 | 143.6 | 141.8 | 138.20 | 132.8 | 136.4 | 4,400,000 | 6,550 | 99.8 | Bovine tuberculosis in cream and sediment |
| | | 45 | ..... | ..... | ..... | ..... | ..... | ..... | 140.00 | 131.0 | 136.4 | | 1,450 | 99.9 | None |
| 4(*d*) | Bovine tuberculosis....... | 20 | 145.0 | 137.0 | 141.4 | 147.0 | 135.5 | 140.3 | 137.80 | 133.1 | 136.5 | 780,000 | 4,250 | 99.4 | Bovine tuberculosis cream and sediment |

(*a*) Run 1. Atttempt was made to pasteurize 120 gal. of milk for 20 min. at 145°F.
(*b*) Run 2. Attempt was made to pasteurize 100 gal. of milk for 20 min. at 140°F.—shows defects of this type of machine during first 5 to 7 min.
(*c*) Run 3. Attempt was made to pasteurize 100 gal. of milk for 20 min. and for 45 min. at 140°F.
(*d*) Run 4. Attempt was made to pasteurize 100 gal. of milk for 20 min. at 140°F.

min. Several holding tanks in series are more trustworthy than one, for the first tank acts as an equalizer and the others hold the milk at the desired temperature. Pasteurizing plants should be under official control for they are too important in preserving the public health to be left to the caprices of the individual.

5. **Advent of the Holder Process.**—The fifth important factor in establishing faith in pasteurization was the development of the holder process. With the perfection of machinery that made commercially available a process of pasteurization which was endorsed by medical men as effective and as not materially altering the milk, public confidence in pasteurization was largely restored.

6. **Success of Child Welfare Stations.**—The convincing work of child welfare stations influenced the public favorably toward pasteurization. The pioneer work of Hoplik, the widely advertised work of Straus and of a shoal of others in all parts of the United States who distributed pasteurized milk to the children of the poor with good results, familiarized people with this new product and satisfied them that it was safe.

7. Finally, it became appreciated that if any large percentage of the entire milk supply of the public was to be pasteurized it must be done outside of the home. A small amount of milk might be pasteurized for children but it was too much of a tax on the overburdened housewife to expect her to pasteurize the milk of the whole family. Furthermore, it was as desirable that the milk consumed in restaurants and hotels should be pasteurized as that the milk drunk at home should be, and it was unlikely that this would come about except the milk should be sold already pasteurized by the contractor.

**Pasteurizing Machines.**—The machines that are used for pasteurizing should be simple, durable and easily cleaned. An intricate machine is more liable to accident than is a simple one; therefore it is not as good, for it must be dependable since the efficiency of the pasteurization is interfered with by interruptions. The machine ought to be durable because it receives constant wear from daily use which it must be able to bear well or else the money that is spent in repairs and replacements becomes an excessive tax on the business. As heated milk is prone to stick to pasteurizers they must needs have a thorough cleaning daily. This requires labor and money; so to keep the expenditure thereof at a minimum the machine should be easily cleaned. Moreover, a pasteurizer with difficultly accessible parts will not be thoroughly cleaned and so will be likely to contaminate the milk. In type, the pasteurizer should be adapted to the business. A small dairy with a fixed trade needs a different machine from a large one with a rapidly expanding business. Whatever pasteurizer is chosen it should have a capacity greater than the demand that will be made upon it for forcing a machine always results in a poor product. Pasteurizing is done either in vats or by running thin

sheets of milk over hot surfaces; these are better heated by a hot water jacket than by steam for the temperature is more easily controlled and the milk is less likely to be scorched.

A pasteurizing unit proper may consist of one or of two parts. In the flash process there is only the heater; in the holder process there is a heater and also a holder or a retarder, while the bottle process accomplishes the heating and holding in a single machine. The different types of pasteurizers have been grouped according to their mode of operation by Kilbourne and also by Ayres. The following arrangement follows their suggestions.

*Type* 1.—The Danish heater. In this machine there is a revolving paddle in a milk chamber that has a water jacket which is filled by injecting steam from three jets till it condenses and fills the jacket with hot water. Milk is fed through an inlet into the bottom of the chamber and by the centrifugal action of the paddle is thrown against the sides of the hot water jacket, being forced out at the top through the milk outlet pipe in which is a thermometer for taking the temperature of the outgoing pasteurized milk.

The advantages of this type are its small cost, ease of cleaning and power to lift the milk about 4 ft. to a holder or cooler.

*Type* 2.—This pasteurizer consists of a cylinder surrounded by a water jacket that is heated by a steam discharge into the water pipe connected thereto. Within the cylinder is a revolving drum to which milk is carried through the milk inlet, and which in revolving, by centrifugal action spreads the milk over its surface in a film, between it and the hot water jacket, finally discharging the milk through the outlet with force to raise it several feet.

*Type* 3.—This is a machine consisting of a conical surface that is constantly wiped by a tape attached to a revolving frame and that is heated by steam discharging into hot water beneath the cone. Milk is run through the bottom of a reservoir over the top of the cone and flows down its sides, being kept from burning by the action of the tape, into a trough whence it is carried to the holder or cooler.

*Type* 4.—Machines in which the milk flows with a rotary motion, between two or more water-heated upright cylindrical surfaces. Some of these machines are constructed on the regenerative principle by which the outgoing hot milk is utilized to warm the incoming cold milk, thereby economizing heat. The most satisfactory machines of the fourth type are those that operate with large enough volumes of water to allow the water to be used at low temperatures.

*Type* 5.—These machines are coils of double tubes, the internal one carrying the milk and the encasing one hot water that is heated by a steam jet introduced to the water before it enters the coil. In this apparatus the hot water flows in a direction opposite to that of the milk,

thus utilizing the maximum heating power of the water and raising the temperature of the milk gradually. The efficiency of machines of this type depends on securing a slow enough flow of the milk and sufficient heating surface to certainly heat all of the milk to the required temperature. It is important that these pasteurizers shall be so built that there shall be no danger of intermingling of the milk and water through leakage, and so that they can be easily taken apart for thorough cleaning. The advantages of this type of pasteurizers are that they are built so strongly that they can be sterilized by steam under pressure and that they are constructed in sectional units whose capacity can be increased by the addition of more units as the growth of business demands it. An objection to this apparatus is that the pipes are so slightly inclined from the horizontal that at the end of the run it is difficult to empty all the milk from the machine.

*Type* 6.—Various makes of tanks that are insulated and heated by hot water jackets or in some patterns by revolving screws or coils of pipe, are extensively used for pasteurizing milk on a small scale. The extreme simplicity of the vat system highly recommends it. The life of dairy machinery is short because of the rough usage it must necessarily receive. The simple tanks may outlast the more complicated heater and holders and therefore cost less. They are also economical because the tank may be used as a heater, holder and cooler. The great disadvantage is that it takes a long time to raise the milk to the desired temperature and likewise to cool it. Besides, unless the tank is kept covered the loss from evaporation is considerable. The advantage of the tanks is that the heating of the milk may be checked right at the desired temperature and the milk held there till the tank is emptied. When the tanks are used for cooling, cold water and afterward brine is pumped through the jackets or screws. In some types of tanks the bearings or packing boxes of the agitators come into contact with the milk, and contaminate it with oil. While this is perhaps one of those things that are more unsightly than dangerous it should be avoided if for no other reason than that there is some slight danger of the oil imparting a bad flavor to the milk.

In the spray vat system one tank is contained within another but instead of being cooled by a water jacket filling the space between the inner and outer tank it is cooled by a spray of cold water from a pipe that runs along its upper edge, the spray being delivered in such a way that the jets unite to form a film which runs down the outer surface of the inner tank and away at the bottom. The milk is agitated by blades affixed to a mechanism that travels on the top frame of the vat, thereby eliminating all danger of oil contamination.

*Type* 7.—There is a tank for pasteurizing milk in cans. A double row of cog wheels runs the full length of the tank bottom and on each wheel is placed a 10-gal. can within each of which is a stationary paddle.

The tank is filled with water of the desired temperature and the wheels are set in motion by a drive gear at the end of the tank. Thus the cans revolve and the milk is stirred by the paddle. When the proper time has elapsed the milk is poured from the cans over a cooler.

*Type* 8.—For pasteurizing milk in bottles two types of heaters are used. The first is a tank of galvanized iron or cement, with steam pipes suitably arranged on the bottom and sides for heating the water in the tank to the required temperature. The carefully sealed bottles are stacked in the tank and covered with water which is raised to the pasteurizing temperature and held there for the proper period. Such apparatus is inexpensive and makes pasteurization a possibility for small dairies.

More costly machines for pasteurizing milk in the bottle are put out by the manufacturers of beer-pasteurizing machinery. In these machines cases of bottled milk by various devices are subjected to showers of water that gradually rise in temperature till they reach the pasteurizing point, where they remain stationary for ½ to ¾ hr., after which the temperature of the showers is reduced till the milk is cooled sufficiently for it to be put in cold storage.

The great advantage of pasteurizing in the final package is that the cap, bottle and milk are all subjected to the pasteurizing temperature and are not thereafter exposed to contamination. Besides this, the loss from evaporation that occurs in some of the other processes of pasteurization is eliminated. The chief disadvantage is the cost. The pasteurization has hitherto been done in small units which is an expensive way of handling the milk. The caps used are of types controlled by the several manufacturers thereof so that they are costly and one of these patent caps chips the bottles thereby increasing bottle costs which are also increased by breakage resulting from the strains developed by rapid heating and cooling. Most of the processes that are in use are not regenerative, consequently they are unnecessarily expensive for it is possible to so design the apparatus that the water which is warmed in cooling the hot milk can be utilized in heating up the cold. A good grade of milk can be safely pasteurized in the bottle, but mixed milk collected from divers medium-class producers is likely to be in part made up of the strongly flavored milk of cows approaching the end of the lactation period and of milk that has an unpleasant odor derived from forage, bacterial growths and other sources and such milk is apt to give trouble because the heating may intensify the odors to the detriment of the milk since they have no chance to escape.

The process, advocated by Ayres and Johnson, of bottling hot milk, is in effect a special development of the holder process. Milk heated to about 145°F. is filled into hot steamed bottles and is capped and then cooled by an air blast. The advantages claimed for the process are: an excellent bacterial reduction; no liability to bottle infection; elimination

of loss from evaporation in passing over the cooler; and that ordinary cardboard caps may be used to seal the bottles. The disadvantages are several. To the cost of cooling the hot milk is added that of cooling the hot glass bottles and the cases that hold them. One quart bottle weighs about as much as the milk it contains and it has to be cooled from 145°F. to 40°F. or lower. Ayres, Bowers and Johnson have recently published the results of their investigations on cooling hot bottled pasteurized milk with forced air. As there is very little difference in the relative rate of cooling milk and water they found it advisable to use water in their experiments but distributed bottles of milk throughout the crates for temperature readings and for bacteriological studies. They found that: 1. A bottle of hot milk will cool about one-third faster in circulated than in still air and that this is also true of milk in cans but that since in cooling by this method the time required is chiefly dependent on the size of the container, quart bottles are about as large sized vessels as could be used in commercial practice. Cooling hot-bottled milk by natural circulation of air is too slow for practical work. 2. In their experiments, which were conducted on a basis of 30 crates stacked in six piles, each five crates high, it was found that when cold air was forced up through the crates, there was too much variation in the temperature of the same sized bottles in different positions in the stack and also in that of quart and pint bottles in the same position to admit of successfully cooling in this way in commercial work. 3. Better results were obtained by reversing the direction of the cooling air first up and then down through the crates every 15 min. during the cooling period but this way was not wholly successful. 4. Satisfactory results were obtained by forcing the air from the top downward. This cools the milk in the top of the bottles first and the cool milk being of greater density settles to the bottom and in so doing forces the warmer lighter milk into its place. The convectional currents that are then established result in there being a difference of only a few degrees in temperature in the different bottles in the stack and in a considerably greater rate of cooling. When air at 40°F. was forced down through the crates at about 2,500 ft. a minute the bottles were cooled from 140°F. to 50°F. in 2 hr.; when the air was at 30°F. and the rate 1,700 ft. a minute the bottles were cooled through the same range of temperature in 1 hr. and 30 min.; when it was at 20°F. and was forced down through at 1,700 ft. a minute the bottles were cooled from 140°F. to 50°F. in 1 hr. and 20 min. 5. The cost of cooling by forced air circulation when the outside air is at 40°F. or lower, is materially less than that of the usual methods of refrigeration. 6. Bacteriological studies indicate that if the milk is cooled from 145°F. to 50°F. within 5 hrs. after pasteurization, no more bacterial increase takes place than when the milk is cooled immediately to the same temperature. In fact, in these experiments on a 30-crate basis, there was marked re-

duction in the bacterial numbers during the cooling period, especially when the raw milk contained large numbers of bacteria before pasteurization. As the experiments indicate that pasteurized milk can be cooled on a commercial scale from 145°F. to 50°F. by forced air within 3 hr. the process can be completed well within the 5-hr. limit. It is emphasized that the cooling of milk is absolutely necessary and that this process does not eliminate cooling; it merely cools more slowly than is at present customary. 7. So far as could be determined from experiments conducted on this scale, the cream line and flavor of the milk are not injured by this process. 8. These experiments indicate that it is commercially practicable to cool hot pasteurized milk in containers not larger than quart bottles by forcing cold air downward over them, when the air is at 40°F. or lower.

On account of overheating portions of the milk, the process of pasteurizing milk in bottles by forcing hot air over them seems commercially impracticable.

Objections that have been raised to bottling milk hot are that the air space that is formed in the bottle by the contraction of the milk in cooling both makes the package unattractive to the consumer and gives opportunity for the milk to churn as it is carried about in the delivery wagons.

**Holders.**—Holders are of two principal sorts, namely; the absolute or positive and the continuous holders or retarders. In the absolute holders the heated milk is actually held in insulated or jacketed tanks or compartments for a definite period of time, usually 20 to 45 min. and at the pasteurizing temperature. They are very efficient, provided all the milk is held the full time, and provided the temperature is maintained. In some holders of this class scum formation is excessive and impairs their effectiveness because the foam is considerably cooler than the milk and so the contained germs escape destruction. Excessive foam formation greatly increases the surface of the exposed milk, consequently the evaporation therefrom causes undue shrinkage in the milk.

Holders of the absolute type:

1. The combined heating, holding and cooling tanks described as type 6, under heaters.

2. A tank divided into compartments each of which has at the bottom an outlet valve that is operated by an arm connected to a center shaft that passes up through the machine and makes one revolution in 30 min. At the top of the shaft is a distributing trough that fills the compartments. The emptying device is so arranged that six of the compartments are full at a time, while of the two others one is being emptied and the other filled. In this way a compartment after being filled with hot milk is held for 30 min. after which it is automatically emptied. The compartments are arranged so that when the machine is going at full capacity

they are full, while at half capacity they are half full, which permits the pasteurizing of small batches of milk.

3. The holder consists of eight shallow pans arranged in two tiers and supported in an insulated copper-lined case with enamel sides. The intake from the heater discharges automatically and alternately into the top pan of each tier, the milk being held positively in each pan one-fourth of the total selected holding time and then being automatically passed to the pan below. It is claimed that the passage of milk from one pan to another makes agitators to prevent separation of the fat solids unnecessary.

**Holders of the Continuous Type.**—The continuous method is less satisfactory than the positive; the milk is retarded in its course to the cooler so that theoretically it is kept at the pasteurizing temperature long enough to ensure its being thoroughly pasteurized. In reality, owing to the unequal movement of different parts of the milk stream, some of the milk travels toward the cooler more rapidly than the rest and so is inadequately heated. The machines never work up to their rated efficiency. There are three general types of retarders:

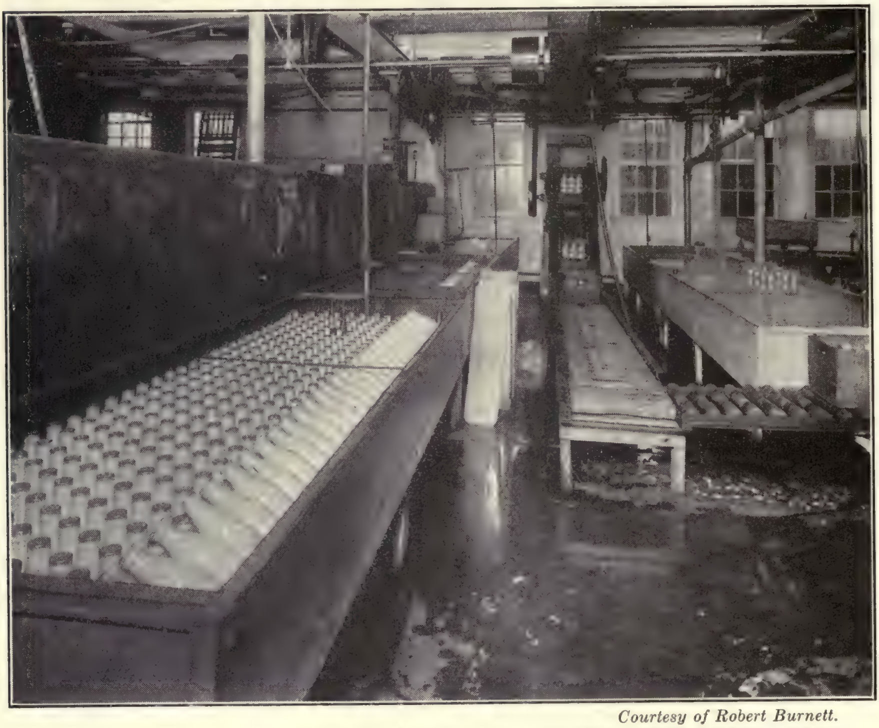
1. This apparatus consists of an upright cylindrical tank or of two or more such tanks arranged in series. The milk is fed in at the top and passes out at the bottom into another tank or if a single tank is used the outlet pipe is carried up nearly to the top of the tank and downward again to the cooler, thus permitting no milk to discharge from the tank till the milk therein reaches the level of the top of the outlet pipe. Single tanks are unsatisfactory for the milk tends to stratify with the hot milk at the top, consequently the milk in different parts of the tank is held unequally. Holders of this type are difficult to clean and are said to have a holding efficiency of but 25 to 50 per cent. of their theoretical capacity.

2. Holders of this sort are horizontal tanks with cross-partitions or baffles to impede the flow of milk through the tank from one end to the other. The best show an efficiency of from 10 to 15 per cent. of their theoretical capacity.

3. Machines of this type are horizontal tubular holders in which the milk enters the topmost of a series or bank of tubes and passes backward and forward through them all, till it emerges from the bottom tube. Tubular holders have an efficiency of from 80 to 85 per cent. of their theoretical capacity. As in the case of the tubular heaters, it is difficult, owing to the slight inclination of the tubes, to remove the last milk at the end of the run. Pains must be taken to clean the tubes thoroughly. Heaters of every type must be warmed with steam before running milk through them, otherwise the first milk to pass is apt to be cooled below the pasteurizing temperature with the result that the bacteria it contains are not killed.

**Regenerative Pasteurizers.**—The object of regenerative pasteurizers is to economize heat and ice. This is effected by utilizing the hot milk

from the heater or holder to heat the cold raw milk on its way to the heater. There are several ways of arranging the apparatus to do this; the heating of the cold milk may take place within the heater or in the cooler. If it is done within the heater the pasteurized hot milk in the course of its passage to the cooler through the machine is forced over a surface against the other side of which the incoming cold flows. So the hot milk gives up heat to the cold milk. In case a holder is used with such machines the hot milk from it is returned to the heater and following the usual course to the cooler heats the raw milk on the way. Where the regenera-



*Courtesy of Robert Burnett.*

FIG. 42.—Pasteurizing milk in the bottle at Deerfoot Farms, Southboro, Mass.

tion is accomplished in the cooler, the pasteurized hot milk passes from either the heater or holder to the cooler and flowing down on the outside of the cooler warms the cold milk which in some types of coolers passes through the inside of the cooler and in others runs down one side of the cooler while the hot milk runs down the other. By the regenerative process the temperature of the cold raw milk on its way to the cooler is raised through 40°F. or more while the hot milk that is passing over the cooler is chilled a like amount; thus a saving of both steam and ice is effected.

The invention of the Dacro metal cap by William Painter in 1892 and

the putting on the market, in 1910, of a size thereof especially adapted to milk bottles made it possible to submerge the bottles for pasteurization and led to the adoption of pasteurization in the final package on a commercial scale. Since that time other caps adopted to this sort of pasteurization have appeared. One of the first to adopt the bottle process was Robert Burnett who has used it under the direction of Prescott at his Deerfoot Farm in Southboro, Mass., since Aug. 1, 1911. D. Whiting & Sons, also of Boston, under the direction of Stedman Bixby have pasteurized a part of their supply by this method since September, 1911.

In practical work the bottles are filled with milk to a level that leaves about 2 per cent. of their total capacity as an air space. They are then capped and heated in water that has a temperature of about 150°F. for a period of 30 min. from the time the milk reaches 145°F. They are then gradually cooled and are finally put in cold storage. Commercial houses have long had data as to the efficiency of the method but Ayres and Johnson and also Hammer are the first to publish results of careful studies of the process.

The two former authors find that pasteurization in the bottle at 145°F. for 30 min. gives satisfactory bacterial reductions. They advise that in order to destroy heat-resisting organisms, which may survive the pasteurizing temperature, the bottles be steamed for at least 2 min. before being filled with milk. They observe that during the period the milk is being heated the temperature varies markedly in different parts of the bottle. If milk at 50°F. is heated in bottles without agitation, in water at 146°F., the temperature at the top of the bottle will reach 140°F. about 9 min. before that in the bottom does. In actual pasteurization the bulb of the thermometer should be placed about ½ in. from the bottom of the control bottle. If bottles with chipped or otherwise imperfect tops are used, serious contamination of the milk may result from leakage of the water into the milk.

Hammer's results are in general accord with those of Ayres and Johnson, but he advises an exposure of 50 min. in water at 145°F. for milk in half pint, pint and quart bottles and, basing his opinion on experiments with pint bottles, concludes that this exposure would be satisfactory also for cream. Milk pasteurized at 145°F. for 50 min. soured slowly with a typical lactic acid curd and without gas formation. As the vat temperature was increased above 145°F., the results were progressively undesirable until at temperatures between 160° and 170°F., the cream line was interfered with and a cooked flavor imparted to the milk. The flavor of the milk, pasteurized as recommended, was acceptable to most people. Undesirable flavors in the raw milk were not decreased by this method of pasteurization and sometimes they were intensified. In some cases a flavor was imparted to the milk by the paper lining of the cap and to remedy this the manufacturers made a cap with a parchment paper lining. Instances

occurred of a cream, with a trifle higher acidity than usual, giving on pasteurization a thin layer of free fat and imparting a granular feel to the tongue.

**Bottling Milk Hot.**—With regard to bottling milk hot Ayres and Johnson concluded that as good or even better bacterial reductions can be obtained than when the milk is pasteurized in the bottle. Bottle infection is eliminated, even when several cubic centimeters of old sour milk are added to the bottles before filling them. The 2-min. steaming that bottles receive before being filled with hot milk destroys the contamination. Laboratory experiments indicate that milk may be pasteurized, bottled hot, capped with ordinary cardboard caps and cooled with a cold air blast. It is probable that if milk is cooled from 145°F. to 50°F. within 5 hr. no greater bacterial increase will take place than if it is cooled at once to 50°F. Future experiments will be necessary to determine whether this will be true under commercial conditions. So far as laboratory experiments show, milk that is heated to 145°F. for 30 min. and bottled hot, when subjected to slow gradual cooling through periods of less than 5 hr. duration, is liable to no more trouble with the cream line and with off flavors than is milk pasteurized and cooled in the usual way. A quart of milk in cooling from 145° to 50°F. shrinks about 0.62 oz.; so slightly oversized bottles should be used for bottling milk hot.

**Difficulties Encountered in Pasteurization.**—In commercial pasteurization difficulties of different sorts are encountered. Milk occasionally coagulates in the pasteurizing apparatus. Harding and Rogers state that it has been found impractical to pasteurize milk intended for immediate consumption when the acidity is over 0.2 per cent. calculated as lactic acid, and in the course of their experiments on the efficiency of a continuous pasteurizer, having a steam-heated jacket, they found that as the acidity approached 0.36 per cent. a considerable layer burned fast to the sides of the milk chamber of the pasteurizer and the accumulation in the separator bowl was increased. The question was studied by Kastle who concluded from his own results and those of others that the coagulation of milk is dependent on several factors among which are: time, temperature, degree of acidity, quantity and nature of the calcium salts, etc.; and that in order to avoid accidents resulting from curdling in the pasteurization of milk, the only safe rule to follow is to determine the effect of heat on small samples of milk which it is proposed to pasteurize.

A cooked flavor is noticed by many consumers in milk heated to 158°F. It is probably due to the effect of heat on the milk sugar and may be avoided by the use of low temperatures in pasteurization.

Much trouble has been experienced from the fact that pasteurized milk may have an ill-defined cream line and may show shrinkage in the volume of cream that rises to the top of the container. The accepted explanation of this fact has been that in raw milk the fat is in clusters

which, being lighter than the serum of the milk and having a relatively small surface in proportion to their cubic content, readily rise to the surface to form cream, whereas in the heated milk the clusters are disrupted and the single globules fail to rise to the surface because they have relatively large surfaces which meet enough resistance to offset the force of gravity that tends to make them rise. Recently, Peter of the Swiss Dairy School in Berne has shown that the rapidity of the formation as well as the depth of the cream line increases up to a pasteurizing temperature of 141.8°F. beyond which it decreases, but even at 145.4°F. was greater than in raw milk. So the usual explanation cannot be accepted; instead it is held that heating decreases the viscosity of milk and so facilitates the rising of the fat globules but that at temperatures above 145.4°F. an abundant though invisible coagulation of the albumen retards or prevents the rising of the fat globules. Kilborune investigated the question and found that when milk is cleaned by the centrifugal clarifier the volume of the cream in the milk is reduced 2 to 3 per cent. He found, too, that the volume of cream in bottled milk is affected by several imperfectly understood factors, viz.:

1. The temperature to which the milk is heated.
2. The length of time at which the milk is held at high temperature.
3. The temperature of the heating medium with which the milk comes into contact during the heating process.
4. The clarification of the milk.
5. The amount of agitation to which the milk is subjected especially while hot. This is an important factor. It was noted that in those plants where there was most agitation of the milk and particularly when pumping of the hot milk was practised, the most difficulty with the cream line was experienced.

Other factors that he believed might possibly affect the cream line are:

1. The age of the milk at pasteurization.
2. The grade of the cows that produced the milk.
3. Whether or not the milk had been frozen before pasteurization.

As a result of these studies the New York City Board of Health now requires that for milk to be considered pasteurized it must have been exposed to temperatures between 142°F. and 145°F. for not less than 30 min.

There is some evidence that the method of cooling the milk effects the volume and character of the cream. There are experiments which indicate that in vat pasteurization, if the milk is cooled in the vats, a slow process, the cream line is not very distinct, whereas if the milk is cooled quickly by running it out of the tanks over coolers the cream line is sharply defined and the cream on analysis shows more casein than does the slowly cooled cream.

Excessive loss from evaporation is to be guarded against in pasteurization. For that reason the heated milk should not be exposed to the

air. Probably the greatest loss occurs when pasteurizing is done in open vats or the cooling is done over an open cooler. To prevent loss from the latter source many firms use an internal cooler of the type that has one set of tubes enclosed within another. Usually such coolers are regenerative, the incoming cold milk being used to cool the outgoing pasteurized milk and being itself heated in the process. It is impossible to state the loss that occurs from evaporation because it varies so much in different plants. In some it amounts to as much as 4 per cent. of the milk pasteurized but this is excessive; with careful management it should be kept under 1 per cent.

Besides the loss of milk that evaporation causes, there is that which arises from spilling the milk in passing it through the pasteurizing machinery and from that which is left behind in the machine. This, too, varies greatly in amount, being little in some plants and large in others according to the care and types of machines used.

The tendency of the treated milk to froth or foam causes considerable trouble because it makes the milk difficult to handle, because it tends to produce excessive evaporation, and because the foam is likely to be several degrees cooler than the body of the milk in the holder and so to cause imperfect pasteurization. The trouble has been overcome to some extent by filling the holders from the bottom.

Milk should never be pumped after it is pasteurized because it is likely to be recontaminated and because, if the pumping is done while the milk is hot, the volume of the cream that will rise on it is greatly reduced.

At certain seasons of the year there is a tendency for the cream of pasteurized milk to form a tough leathery layer on top of the milk. This is believed to be due to needlessly rough handling in the course of pasteurization and to occur at those seasons when atmospheric temperatures approach those of churning, about 62°F.

**Importance of Temperature Control.**—The vital part of pasteurization is the use of the proper degree of heat; hence temperature control is of the utmost importance. Skill and care are required to successfully operate a pasteurizer. In the first place in starting a machine the temperature rises gradually and the apparatus as a whole is not promptly heated to the required temperature so that the first milk to pass is apt to be underpasteurized. Therefore, it is customary to run it through the machine a second time; when this is done the milk should not be allowed to pass over and contaminate the cooler before being returned to the heater. In some plants hot water is run through the apparatus to heat up and sterilize the apparatus. This procedure is excellent but care must be taken to remove all of the hot water before actual pasteurization is begun. Again, in starting it takes some machines time to settle down to the maintenance of even temperatures and until they have done so the milk they are han-

dling is likely to be imperfectly pasteurized. After the machine is started and running well interruptions from non-arrival of the milk at the plant, breakdown of the machinery, neglect to keep up steam pressure, and other accidents may cause failure. Besides, if the work is late or there is an extra amount of milk to be pasteurized, the machine may be crowded at the expense of efficiency. Also, since overheated milk is almost certain to cause complaint from customers, there is the constant temptation to pasteurize close to the lower temperature limit which means that the heating it is apt to be insufficient to kill the pathogenic germs. So, it is imperative that every pasteurizing plant shall employ efficient methods of controlling the temperature and of recording that actually used during the entire run.

Ayres states that a competent man in a small plant by hand control can regulate the pasteurizing temperature within 2° or 3° each way but that in large plants mechanical control is much more certain for there are numerous controllers that will run within 1° each way, of the desired temperature. The underlying principle of automatic control is the regulation of the steam flow by a diaphragm valve, operated by air pressure, regulated by expansion and contraction in the controller bulb which is placed in the milk outlet of the pasteurizer. By setting the controller any desired temperature may be obtained. The bulb of the recording thermometer is inserted in the milk as it leaves the pasteurizer and registers on a chart a continuous record of the temperature maintained during the run. Care should be exercised that the controller and recorder bulbs are affected only by the temperature of the milk for if they are exposed to warm surfaces, or escaping steam or if they are placed where the circulation of the milk is sluggish, erroneous results will be obtained. The U. S. Department of Agriculture states that relatively few plants are using automatic temperature controllers and urges their adoption, saying that the power used in operating them is not greater than the steam wasted, where hand control is used and estimating the daily overhead expense of the instruments at 11 cts., or less than the wage of one man for an hour. The temperature chart not only shows the temperature used at any period of the process but in all holder systems, except those using retarders, shows the period of time through which any temperature was maintained. Thus these charts are valuable evidence as to the efficiency with which the pasteurization is conducted. So, boards of health in some principal cities of the United Stated require the use of continuous temperature recorders and it would seem wise for other cities to follow their lead, for such records are the best possible guarantee that pasteurization is being properly done. The validity of the Chicago ordinance which requires the use of continuous temperature recorders has been upheld by the courts in Koy *vs.* the City of Chicago et al., Ill., 104, N. E. R., 1,104.

**Actual Pasteurization.**—In actual pasteurization the first thing is for the operator to assure himself that the apparatus is in condition to start the run. It is assumed that the apparatus is so placed that the milk in the course of its passage is not unnecessarily exposed to dust and that at the close of work on the preceding day the whole outfit was thoroughly scrubbed and rinsed. So the inspection preliminary to starting the run should be a close one in which the effort is to make sure that the apparatus is set up properly and is mechanically sound that the run may proceed without interruption and to detect any dirt that may lurk in seams, turns and corners. Then, because dust has settled on the machinery since it was scrubbed, every piece is given a final cleansing. The receiving tanks are rinsed with hot water and blown out with steam. The separator and clarifier are rinsed with hot water. If a strainer is used, pains are taken to see that it is in fit condition. Wire strainers are apt to collect cheesy material between the meshes, quartz filters must be carefully washed and sterilized with steam, and cloth filters must be renewed after each run and must be put together carefully. Both the heater and holder are rinsed off with hot water. Dust that has settled on the cooler is rinsed off with hot water and the cooler afterward steamed. The apparatus is then ready for use; the milk is started through and the process conducted in accordance with the procedure approved for the machinery in use. The results should be satisfactory but if they are not, samples for bacterial test must be taken of the milk as it enters and as it issues from each machine that composes thep asteurizing unit, for only in this way can the part that is doing faulty work be located.

**Efficiency of Pasteurization.**—The efficiency of pasteurization is commonly judged by the reduction that is affected in the bacterial content of the raw milk. This is stated either by giving the numbers of bacteria in both the raw and the pasteurized milk, as for example 10,000,000 per cubic centimeter before and 200,000 after pasteurization, or by giving the percentage of reduction accomplished, which is sometimes called the "bacterial efficiency," as for instance 98 per cent. This is sometimes misleading, in this way; a bacterial efficiency of 98 per cent. on a milk that contained 10,000,000 bacteria per cubic centimeter would mean that there would remain in the milk 200,000 bacteria per cubic centimeter whereas with the same efficiency on a milk that contained 10,000 bacteria per cubic centimeter, but 200 bacteria per cubic centimeter survived. Ayres and Johnson show that the percentage of bacterial reduction has no special meaning since it is influenced by the numbers and kinds of bacteria in the milk pasteurized. As a general rule, when there are many bacteria in the raw milk there will be a high, and when there are few there will be a low, percentage reduction. While the bacterial count is a good index of efficiency, it is open to criticism on the ground that it makes the assumption that a high reduction in the count shows the destruction of pathogenic

bacteria. Since the disease-producing organisms and viruses that are commonly carried in milk have thermal death points below the temperature of pasteurization, the assumption is generally correct but it is entirely possible that heaters that heat the milk unequally, or holders that do not hold *all* of the milk the full period, or retarders that permit the passage of portions of the milk more rapidly than others, or slack operation of the plant might show bacterial reductions and yet there might be failure to kill all pathogenic bacteria. Low bacterial counts backed by temperature record cards and by faithful inspection are a safer guarantee of efficiency than the counts alone. It may seem to some that the logical way to test the efficiency of pasteurization would be to look for disease germs in the pasteurized milk and so it would be, if bacteriological technique was developed to the point where this could be quickly and certainly done, but it is not.

**Method of Cooling.**—After pasteurization milk must be cooled. It was formerly held that sudden cooling was essential for it was believed that it helped to destroy the bacteria. Ayres and Johnson made some experiments—Table 84—which show that this is not so. The value of the sudden cooling lies in this; that after pasteurization the milk is prevented from slowly cooling through temperatures around 100°F. where bacterial multiplication is sure to be rapid.

TABLE 84.—EFFECT OF SUDDEN COOLING ON THE BACTERIAL CONTENT OF PASTEURIZED MILK (AYRES AND JOHNSON)

| Sample No. | Bacteria per cubic centimeter in raw milk | Pasteurized at 145°F., 30 min. | | Sample No. | Bacteria per cubic centimeter in raw milk | Pasteurized at 160°F., 30 min. | |
|---|---|---|---|---|---|---|---|
| | | Bacteria per cubic centimeter in milk not cooled | Bacteria per cubic centimeter in cooled milk | | | Bacteria per cubic centimeter in milk not cooled | Bacteria per cubic centimeter in cooled milk |
| 1 | 186,000 | 8,600 | 8,500 | 3 | 400,000 | 1,880 | 1,950 |
| 2 | 233,000 | 1,470 | 2,160 | 4 | 1,350,000 | 1,750 | 1,700 |

Later these authors studied the question of how quickly milk must be cooled in order to check bacterial growth and in the course of their investigation made three experiments to show respectively the effect on the bacterial content of cooling quickly, slowly and not cooling at all. Milk was pasteurized in bulk and the hot milk filled into three steamed hot quart bottles. One bottle was cooled in ice water in ½ hr. to 50°F. and refrigerated at 45°F. Another was cooled in a blast of air at room temperature for ½ hr. during which time the temperature of the milk dropped from about 145°F. to 80°F. in 5 hr. after which it was placed in a refrigerator at 45°F., where it cooled slowly in still air. The third bottle was cooled for ½ hr. in an air blast at room temperature and held at about 75°F. throughout the experiment. The results are given in Table 85.

TABLE 85.—EFFECT OF DIFFERENT METHODS OF COOLING ON THE BACTERIAL CONTENT OF PASTEURIZED MILK (AYRES AND JOHNSON)

| Method of cooling | Sample No. | | |
|---|---|---|---|
| | 1 | 2 Bacteria per cubic centimeter | 3 |
| Raw milk | 9,050,000 | ........ | 11,900,000 |
| Bottle No. 1 cooled quickly | | | |
| Directly after pasteurization | 6,450 | 2,110 | 9,500 |
| Held at 45°F. for 22 hr. | 5,050 | 1,720 | 28,400 |
| Held at 75°F. for 6 hr. | 4,800 | 2,340 | 76,500 |
| Held at 75°F. for 24 hr. | 1,370,000 | 885,000 | ......... |
| Bottle No. 2 cooled slowly | | | |
| Directly after pasteurization | 7,150 | 2,580 | 11,900 |
| Held at 75°F. for 5 hr. | 6,100 | 1,600 | 29,000 |
| Held at 45°F. for 17 hr. | 6,200 | 2,400 | 192,000 |
| Held at 75°F. for 6 hr. | 9,600 | 2,740 | 348,000 |
| Held at 75°F. for 24 hr. | 2,760,000 | 850,000 | ......... |
| Bottle No. 3 cooled at room temperature | | | |
| Directly after pasteurization | 4,950 | 2,180 | 8,500 |
| Held at 75°F. for 5 hr. | 6,850 | 2,890 | 25,000 |
| Held at 75°F. for 22 hr. | 700,000 | 2,420,000 | 83,400,000 |
| Held at 75°F. for 28 hr. | 2,750,000 | 13,400,000 | 269,000,000 |
| Held at 75°F. for 66 hr. | 460,800,000 | ........ | ......... |

The table shows no increased bacterial growth in samples 1 and 2 from holding the pasteurized milk 5 hr. after bottling hot, even though the temperature ranged between 80° and 100°F. which limits comprise the temperatures most favorable for bacterial development. In sample 3 the milk that was cooled slowly does show an increased growth over that which was cooled rapidly, but even so it is to be remembered that the experiments represent extreme conditions in slow cooling and so it would seem proper to infer from the three samples that the cooling process can be delayed but that it should not extend over 5 hr. The writers make application of this in their process of cooling with an air blast, milk bottled hot. They strongly emphasize the fact that the table shows that milk not cooled to low temperatures soon has a higher bacterial count than either milk cooled slowly or that cooled rapidly, which should drive home the practical point that milk must be cooled to low temperatures after pasteurization.

**Inspection of Pasteurizing Plants.**—The inspection of pasteurizing plants by those in official position should be done in a systematic and thorough manner. The description by Sturgis of the way it is done by the Department of Health of New York City gives a clear idea of how such work should be conducted.

"The complete inspection of a pasteurizing plant involves the examination before, during and after the operation, in order to note the condition of the apparatus and the care given to its cleanliness at all times, as well as to watch the

actual handling of milk. The inspector, therefore, first carefully examines all pipes and connections, pumps and other apparatus used in handling the milk, taking the various fittings apart, if necessary, to assure himself of their cleanliness. He also watches the sterilizing of pipes and vats before their use, which process serves also to enable the first milk to hold its temperature without undue loss. During the actual handling of milk the inspector notes its condition upon receipt as to dirt, temperature, sweetness, etc., and watches to see that it is not exposed to dust or dirt. The temperature during its pasteurization is recorded automatically upon the dial of a clock recorder, the accuracy of which is tested at each inspection. These recording devices will also indicate the holding period in certain forms of absolute holders, but will not perform this function in the case of continuous retarders. In this latter type of apparatus the holding period is best ascertained by watching the speed at which the milk is dumped through them. Upon leaving the holders the milk must be cooled quickly to a low temperature, preferably from 40° to 45°F. or even lower and then immediately placed in the cans or bottles in which it is to be shipped. The inspector notes the temperature of cooling at frequent intervals, and is thereby enabled to advise if the hot milk is fed to the cooler too fast to obtain good results, and have the flow regulated in accordance. The cleanliness of bottles and cans used for holding pasteurized milk is a feature of great importance. The aim of the department is to obtain sterility of containers after they have been cleaned, and here the personal effort of the inspector can often accomplish better results than any prescribed set of regulations. Bacteriological examinations of rinsings with a sterile water control is the guide that is followed, and inspectors are kept closely informed of all such results. The commonly accepted standard in such cases is a count of 1,000 for bottles and of 40,000 for cans, 50 c.c. of sterile water being used.

"After pasteurization for the day is concluded attention is directed first to the correct labeling of the milk and its refrigeration pending shipment, and then the important feature of thoroughly cleaning the apparatus. First of all the pipes and pumps must be taken apart and each length or piece washed, scrubbed and rinsed. A plentiful supply of hot water and a liberal use of it is essential. Then after the apparatus is assembled again it must be sterilized by live steam for at least half an hour. After this is done empty cans and bottles returned from the city are washed, rinsed and steamed in order to be ready for the following day.

"The schedules of inspection are arranged so as to provide that samples of the milk are taken during inspection of pasteurizing plants at stated intervals. Four samples are taken at each of the various steps and from these four individual samples an average is obtained which fairly reflects the quality of the milk and also serves as a check upon the thoroughness of pasteurization. Usually these samples are taken from (*a*) the raw milk, (*b*) at the outlet of the holder or after the milk has been heated and held, (*c*) from the outlet of the cooler, (*d*) from bottles or cans that have been filled for shipment. These samples are thoroughly chilled, packed in ice, and shipped in the milk car to the city terminal where they are collected upon arrival and taken to the laboratory.

"There are so few occasions during inspections of pasteurizing plants that fail to show some defect, serious or trivial, in equipment or operation, and the conjunction of a number of defects trivial in themselves so frequently constitutes

an aggregate that is serious, that it is impossible to even imagine the proper conduct of such plants without supervision of an inspectorial nature."

**Sterilization of Milk by Electricity.**—The question is often asked whether it is possible to sterilize milk by electricity. The process of the Goucher Electric Purifying Co. does so. The milk is filtered through cheese cloth and absorbent cotton into a large tank where it is kept in constant motion to prevent the cream rising. From the tank it is pumped through pipes to an electrical purifying apparatus, being subjected on the way to a steam temperature which can be regulated to any desired degree. In the electrical purifying machine the milk is exposed to an alternating current of 1,920 to 1,960 voltage and 7.5 to 8.5 amperage. The current is obtained through a 1 to 10 transformer. By exposure to the current the milk is raised in temperature, consequently the temperature of the milk on issuing from the electrical machine is the temperature it had on entering it plus the temperature acquired in the machine, which means that the final temperature is in measure determined by the degree of steam heating it receives. As the process is often operated, the milk is heated to about 150°F. by steam and is raised to 164°F. by the electrical apparatus. From the electrical machine the milk runs over coolers to a bottling tank. The passage of the milk from the receiving tank through the steam-heated pipes and electrical machine to the bottling tank is said to take less than a minute so that the process partakes of the nature of flash sterilization. The proprietors put out literature giving the findings of several commercial laboratories that the process effects a good bacterial reduction, destroys disease germs, does not alter the chemical constitution of the milk and tends to increase rather than to decrease the volume of the cream layer. No data is available as to the cost of purifying milk by this process.

Lewis in England reports tests with an apparatus for pasteurizing milk by electricity.

"The current which varies in amount with the size of the apparatus but which normally is between 2,000 and 3,000 volts is applied to the milk by three copper electrodes, each of which is enclosed in an electrode chamber. The chambers communicate with each other by means of stout glass tubing of even bore. The electrode chambers and the intermediate portions of glass tubing are connected by socket joints of India rubber; the whole being built in sections and fastened in this way to facilitate cleaning and to make the apparatus somewhat flexible, the bore of the glass or "lethal tube" is relative to the milk output per hour of the particular installation, and the size of the electrode chamber and its enclosed electrode is such as to interfere as little as possible with the flow of milk through the apparatus, and in addition to allow the copper electrode to command the whole bore fully, so that no milk can escape through the apparatus without being submitted to the full action of the current. The electrode is of copper ⅛ in. thick and is connected with an electric cable by a flat plate which by a spring contact is forced against a similar flat plate directly connected to the elec-

tric cable. A high-tension current is used which in commercial practice necessitates the use of devices to protect the operator. Prior to the entry into the lethal tube the milk flows through an aluminum tube; similarly, as the milk leaves the apparatus it flows through a second aluminum tube, both tubes having a direct earth connection. This arrangement prevents any leakage of current into the containing or receiving tanks. Thus attendants are protected against shock. The lethal tube, with its high-voltage connections, is mounted on a slate panel, itself suspended from the back of a glass-panelled upper cupboard. A lower cupboard, the doors of which are automatically closed by the overlapping doors of the upper cupboard, contains the high-voltage transformer. For further protection, in the framework of the two doors of the upper cupboard, switches are placed, which, when the doors are open, are "off" but when the doors are closed are "on." These switches are connected directly with the source of the electric current. When, therefore, the doors are open the electric current is of necessity "off" and the apparatus can be worked only when the doors are closed; the act of opening any of the doors automatically disconnects the electric current. Thus the apparatus is perfectly safe even when worked by an operator not especially skilled in the theory and practice of electricity. The electricity used, normally consists of a low-voltage alternating current which is passed into a transformer and the voltage increased to the desired point. Switches and other controlling gear are mounted on a switchboard from which the whole apparatus is worked.

"The course of the milk through the apparatus is from a receiving tank into a constant-level tank, into the lethal tube, into a covered channel which discharges into each of two auxiliary tanks which empty into the main tank for the heated milk. In starting the apparatus the milk on emerging from the lethal tube is caught in a separate tank; the current is switched on and regulated, when the correct speed of flow is established, the temperature of the milk rises to the normal maximum and the sterilizing process begins. The milk that has heretofore passed the lethal tube is returned to the receiving tank for sterilization. The object of the two auxiliary tanks is to make it possible to reject portions of the batch that for one reason or another are thought to be imperfecly sterilized before they reach the main tank."

The apparatus effects satisfactory reduction in the number of bacteria in the milk, and wholly destroys any *B. coli* and *B. tuberculosis* that are present. It does not alter the chemical composition of the milk.

The large-scale experimental plant was operated 3 months and in that time heated some 9,000 gal. of milk which were distributed in 270,000 bottles for infant use. The total cost including interest and depreciation, wages and fuel, when electricity is 1.5d. per unit is 1.25d. per gallon. In the case of town's gas at 2s. 8d. per 1,000 cu. ft., the total cost is reduced to 96 d. per gallon and is again reduced to 85d. per gallon when producer gas, obtained from anthracite at 30s. per ton, is used. The amount of electricity used is about 0.43 units per gallon of milk.

**Sterilization of Milk by Ultraviolet Rays.**—Preliminary experiments on the sterilization of milk by ultraviolet rays were conducted by Ayres and Johnson. They found that:

"1. When milk is exposed in thin layers to ultraviolet rays there was a marked reduction in bacterial content. (2) That since the temperature of the exposed milk never rose above 86°F., the action of the rays was entirely independent of the action of heat. (3) The most satisfactory method of exposure was over two revolving drums, the tops of which were at a distance of 4 in. below the light tube of the lamp. (4) The two factors of greatest importance in the successful application of the rays were the thickness of the layer and the length of exposure. A thin layer permits a more complete penetration of the rays and the longer the exposure the more chance they have to act. (4) Ultraviolet rays exerted a greater bactericidal action on vegetative cells in milk than on spores when exposed under the same conditions. (6) No greater action of the rays on bacteria was observed when the bacteria were weakened by pasteurization immediately preceding exposure. (7) From the study of two samples of milk exposed to ultraviolet rays it was apparent that the rays did not exert any specific bactericidal power on any particular group of bacteria in the milk. As stated before, however, there was a difference on the action of the rays on bacteria in the vegetative and spore state. (8) Under similar conditions of exposure there seemed to be somewhat less bacterial reduction in 15 per cent. cream than in milk which was probably because the revolving drums picked up a thicker cream layer than milk layer. (9) When milk was exposed under conditions suitable for a satisfactory reduction of the bacteria by the ultraviolet rays there was also produced an abnormal disagreeable flavor that would render the milk unsaleable. (10) A large percentage of the bacteria in normally dirty and artificially infected milk bottles were destroyed by exposure to the rays."

The best results were obtained when the bottles were exposed directly under the lamp, the top of the bottle being about 4 in. from the lamp tube. When bottles were exposed on one side of the lamp and not directly under it, poor results were obtained. It was not possible to completely sterilize the bottles even after a 10-min. exposure. The authors concluded that with quartz mercury vapor lamps of the present power and construction it would not be possible to completely sterilize milk by the ultraviolet rays; that while by the use of large drums and many lamps bacterial reductions as great as are now secured by pasteurization might be obtained, there is no assurance that the disease germs would be killed, since the rays do not exert a selective action on vegetative cells; that on a commercial scale it would be difficult to control the factors which influence the bactericidal action of the rays and moreover the disagreeable flavor imparted to the milk renders the process impracticable; that it is doubtful whether the lamps could be made to compete with the use of steam in sterilizing the bottles.

Houghton and Davis confirm the conclusion of Ayres and Johnson that the untraviolet rays cannot be successfully used to sterilize milk and state that in this respect their work agrees with that of Romer and Sames and of Juyge. They did not find a perceptible change in the flavor of the milk after it was illuminated.

TABLE 86.—RESULTS OF TESTS AT FIVE MILK-PASTEURIZING PLANTS (BOWEN)

Temperature balance

| | 1 (*a*) | 2 (*a*) | 3 (*b*) | 4 (*c*) | 5 (*d*) |
|---|---|---|---|---|---|
| Raw milk, °F. | 63.50 | 57.86 | 59.40 | 54.00 | 47.60 |
| Regenerator, °F. | ...... | ...... | 131.30 | 107.50 | 124.00 |
| Rise in regenerator, °F. | ...... | ...... | 71.90 | 53.50 | 76.50 |
| Rise, per cent. | ...... | ...... | 84.00 | 60.53 | 78.30 |
| Heater, °F. | 146.00 | 150.40 | 145.00 | 142.40 | 145.30 |
| Rise in heater, °F. | 82.50 | 92.54 | 13.70 | 34.90 | 21.20 |
| Rise, per cent. | ...... | ...... | 16.00 | 39.47 | 21.70 |
| Total rise, per cent. | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Holder, °F. | 146.00 | 150.40 | 145.00 | 142.40 | 143.30 |
| Drop in holder, °F. | 8.00 | 4.24 | 2.25 | 1.33 | 3.90 |
| Drop, per cent. | 9.70 | 4.58 | 2.63 | 1.50 | 3.99 |
| Regenerator, °F. | 138.00 | 146.16 | 142.75 | 141.07 | 141.40 |
| Drop in regenerator, °F. | 29.75 | 34.16 | 63.45 | 57.07 | 83.00 |
| Drop, per cent. | 36.00 | 36.85 | 74.12 | 64.50 | 84.96 |
| Cooler, °F. | 108.25 | 112.00 | 79.30 | 84.00 | 56.00 |
| Drop in cooler, °F. | 44.75 | 54.14 | 19.90 | 30.00 | 10.80 |
| Drop, per cent. | 54.30 | 58.57 | 23.25 | 34.00 | 11.05 |
| Total drop, per cent. | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

COSTS

| | | | | | |
|---|---|---|---|---|---|
| Capital invested in pasteurizing equipment—pasteurizers, vats, coolers, etc. | $5,332 | $3,000 | $2,065 | $3,470 | $6,250 |
| Interest per day on investment at 6 per cent. per annum | 0.876 | 0.493 | 0.339 | 0.570 | 1.027 |
| Depreciation and repairs per day at 25 per cent. per annum | 3.652 | 2.055 | 1.414 | 2.380 | 4.281 |
| Capital invested in mechanical equipment used for pasteurizing—engine, boiler-shafting, etc. | 1,000 | 800 | 380 | 500 | 700 |
| Interest per day on investment at 6 per cent. per annum | 0.164 | 0.131 | 0.049 | 0.087 | 0.115 |
| Depreciation and repairs per day at 10 per cent. per annum | 0.274 | 0.219 | 0.082 | 0.137 | 0.192 |
| Labor for pasteurizing | 3.500 | 1.750 | 1.500 | 3.000 | 3.000 |
| Cost of coal at $4 per ton of 2,240 ton. | 1.032 | 0.582 | 0.166 | 0.634 | 0.425 |
| Cost of cooling water at 50 cts. per 1,000 cu. ft. | 0.848 | 0.480 | 0.109 | 0.158 | 0.009 |
| Cost of refrigeration at $1 per ton | 0.480 | 0.460 | 0.206 | 1.700 | 0.886 |
| Cost of pasteurizing daily supply of milk | 10.826 | 6.170 | 3.865 | 8.666 | 9.935 |
| Cost of pasteurizing 1 gal. of milk | 0.00229 | 0.00262 | 0.00436 | 0.00251 | 0.00387 |
| Average cost for the five plants of pasteurizing 1 gal. of milk | 0.00313 | | | | |

(*a*) Regenerator in heater. (*b*) Surface cooler used as regenerator. (*c*) Direct expansion coils in cooler. (*d*) Cooled entirely by refrigerated water.

**Cost of Pasteurization.**—The average cost of pasteurization is difficult to determine because it varies a good deal in different localities, being dependent on the price of labor, of coal, on the capital invested in machinery, on the temperature of the milk when received at the plant and on other factors of moment. Bowen for the U. S. Department of Agriculture investigated the cost of pasteurizing milk at five representative milk plants and of cream at four cream-pasteurizing plants. All of the city milk plants used the holder process whereas but two of the cream-pasteurizing plants did so.

Some of Bowen's results at the city milk plants are given in Table 86.

Bowen also made tests of the cream-pasteurizing apparatus at four creameries. The apparatus represented both the flash and holder type of machines and pasteurization was accomplished by using (1) live steam, (2) exhaust steam from the engine or from steam-driven pumps and (3) hot water heated by exhaust steam from steam-driven auxiliaries. The acutal cost of pasteurizing cream at each of the four plants was \$0.0456, \$0.0701, \$0.765, and \$0.1101.

The conclusions reached by Bowen were that:

"1. The flash process requires about 17 per cent. more heat than the holder process, consequently the milk or cream must be cooled through a wider range, hence both add to the cost of pasteurizing.

"2. The proper design and arrangement of the heater, regenerator, cooler, piping and refrigerating apparatus have much to do with the efficient operation of the plant.

"3. The loss in heat from poorly arranged apparatus and leaky piping may amount to approximately 30 per cent. of the total amount of heat required to pasteurize and it is practicable to reduce this loss to a negligible amount.

"4. It is practicable to use exhaust steam from the engine and steam-driven auxiliaries, or water, heated by exhaust steam, to furnish heat wherewith to pasteurize both milk and cream. Milk plants usually waste enough heat in the exhaust to do the pasteurizing.

"5. For every 400 lb. of milk pasteurized per hour with exhaust steam approximately 1 hp. is taken off the boiler plant.

"6. The average cost of pasteurizing 1 gal. of milk is \$0.00313 and 1 gal. of cream \$0.00634."

These figures of Bowen's deal with the pasteurizing cycle proper, that is, starting with the initial temperature of the raw milk and raising its temperature to the pasteurizing point and then cooling the milk to the initial temperature of the raw milk. They show the additional expense of producing pasteurized milk over the raw product. The results of Bowen's tests have been quoted only in part and the reader is advised to consult the original paper.

With regard to the present use of pasteurization it may be said that butter and cheese makers have wisely adopted the flash process. In the

city milk business, taking the country by and large, probably more plants are using the flash process but the health codes of the largest cities and of the most progressive large and small ones require the use of the holder process. It is slowly and steadily superseding the flash method and will probably ultimately come to be the only process applied to pasteurizing milk for direct consumption.

There are two reasons for the existence of so many plants of the flash type, namely: (1) that in regions where pasteurization is being newly introduced and without restrictions imposed by boards of health it is apt to be selected because the first cost of installation is often considerably less than for the holder process; and (2) in many places the flash process is used merely because it was installed before the holder process was developed and its merits appreciated.

**Future of Pasteurization.**—With regard to the future of pasteurization it may be confidently predicted that all of the cities of the United States that are able to afford pasteurizing plants will adopt them as necessary instruments to cope with the milk problem. Three reasons assure this, namely: (1) in the present state of preventive medicine it is the only way to protect the milk-consuming public from the dangers of chance infection to which even the best of milk is liable; (2) the expense of maintaining a close inspection of distant and widely scattered dairy farms is prohibitive and in fact none of the large cities or various State boards charged with such work pretend to carry on such inspection; and (3) it is an economic necessity to pasteurize milk in order to prevent great loss ensuing from the growth of large numbers of microörganisms therein. While this wide use of pasteurization is bound to come, it is nevertheless true that there is some danger that the friends of the process may injure its good reputation. Pasteurized milk should be sold for exactly what it is and pasteurization should neither be touted as a cure-all nor represented as making milk *absolutely* safe. Pasteurized milk should be plainly labeled such and the label should state the date, time and temperature of pasteurization. In some quarters there seems to be a tendency to try to persuade that pasteurization may be safely accepted in lieu of dairy inspection and as guaranteeing absolute protection from tuberculosis. Dairy inspection has its place for the health officer certainly ought to know where the milk that is served within his jurisdiction comes from and to be familiar with the farm and farmers who are producing it and also with the methods used in handling it. Without this knowledge it is doubtful if the health code can be either intelligently framed or administered and dairy practice is more likely to become woefully slack rather than to keep abreast of the times. In combating tuberculosis pasteurization is a valuable weapon; it all but prevents children from contracting the disease from milk and if used intelligently in connection with tuberculin testing helps to eradicate the disease at a minimum cost, but to preach

the doctrine that it offers absolute protection against this or any other disease is to deceive. Pasteurization is a mechanical process operated by men and in this imperfect world both fail at times, so that a very high degree of protection is the most that can be honestly promised. The process may be likened to the mechanical filtration of water; this sort of water treatment when operated efficiently with machinery in first-class condition is capable of materially reducing water-borne diseases, but if the apparatus breaks down or is allowed to get into condition unfit for use or if it is either incompetently or dishonestly operated it will fail in greater or less degree according to the gravity of the injury or mismanagement.

Pasteurization of milk is accepted as a necessary treatment of the public milk supply not because it is ideal but because it is practicable. When the pasteurization is done right and the milk protected against subsequent infection and when the pasteurized milk is marketed on its merit without extravagant claims in its behalf the process is a great boon to the milk consumer, but when the milk is pasteurized in any old way that will prevent souring, or when milk is pasteurized over and over again before the consumer gets it, or when pasteurization is used as a club to kill off inspection of dairy farms or tuberculin testing or any other legitimate phase of control of the milk supply, it can be made a curse instead of a blessing. The process probably has enough intrinsic merit to survive any abuse to which it is likely to be subjected but if dairymen and their customers are to enjoy in full the benefits it is capable of conferring it must be used honestly under severe inspection.

**Use of Pasteurization in the United States.**—The general tendency in the United States at the present time is toward the pasteurization of all market milk except that which is certified and that which comes from tuberculin-tested herds. This trend may be observed in Tables 87 and 88.

Table 87.—The Extent of Use of Pasteurization in Cities of the United States of a Population above 25,000 (Ayres)

| Population | No. cities replying | More than 50 per cent. pasteurized | 11 to 50 per cent. pasteurized | 0 to 10 per cent. pasteurized | None pasteurized |
|---|---|---|---|---|---|
| More than 500,000 | 9 | 7 | 2 | 0 | 0 |
| 100,001 to 500,000 | 40 | 12 | 20 | 6 | 2 |
| 75,001 to 100,000 | 19 | 5 | 8 | 4 | 2 |
| 50,001 to 75,000 | 30 | 4 | 15 | 6 | 5 |
| 25,001 to 50,000 | 78 | 13 | 31 | 12 | 22 |
| 10,001 to 25,000 | 168 | 10 | 40 | 18 | 100 |
| Total | 344 | 51 | 116 | 46 | 131 |

TABLE 88.—PERCENTAGE OF THE MILK SUPPLY OF SIX CITIES OF THE UNITED STATES THAT IS PASTEURIZED (AYRES)

| | | | |
|---|---|---|---|
| Boston, Mass. | 80 | Philadelphia, Pa. | 85 |
| Chicago, Ill. | 80 | Pittsburgh, Pa. | 95 |
| Detroit, Mich. | 57[1] | St. Louis, Mo. | 70 |
| New York, N. Y. | 88 | | |

[1] In 1916 practically all milk intended for direct consumption *must* be pasteurized.

*Courtesy of George M. Oyster, Jr.*

FIG. 43.—Milk handling room of the Chestnut Farms Dairy, Washington, D. C.
1st floor: Roller conveyer, rotary fillers, capping machines, and cooler.
2d floor: Pasteurizing vats with automatic temperature recorders.
3d floor: Cooler and storage tanks for cream and buttermilk.
4th floor: Receiving vats.

**Cooling Milk.**—After pasteurization, milk is cooled, bottled and capped, usually in a single room known as the milk-handling room, that is kept immaculately clean, is free from dust and odors, is often wet down with steam before work begins and that while work is in progress is closed to every one save the few white-suited men who are cooling and putting up the milk. Cooling begins right after the milk is pasteurized. There are several types of coolers in use. In the country most of the milk is cooled by putting the cans containing it into tanks of cold water. Very commonly, too, dairy farmers who retail their milk cool it with a Champion cooler, a galvanized-steel bottomed, open-top cone of heavy tin-

plate. Water and ice are put inside the cone and stirred frequently with an agitator to keep the cold water against the cone or cold water is circulated through the cone through an inlet pipe at the bottom and an outlet pipe at the top. From a reservoir on top of the cone milk is discharged through perforated holes onto the cold outer surface of the cone and is cooled as it runs down in a thin sheet into a trough at the bottom whence it drains into a receiving can. Except in the hotter dairy sections and those where neither cold water nor ice are generally available this simple machine has proved a very useful one.

The Star type of cooler also is much used by small dairymen, particularly for cooling cream. It is made of two sheets of heavily tinned copper bent into corrugations and so soldered together at the ends that a space is left between the sheets for water to circulate. Thus the cooler has a fluted surface over which the milk flows in a thin film. Water is introduced to the cooler at the bottom and passes out at the top while the milk runs from a tank into a perforated distributing trough at the top of cooler and down over the cold surface of the cooler into a trough and out through a spout into a receiving can. This is a good cooler but a frail one, for it is made of such thin metal to insure a rapid exchange of heat between the warm milk and the cold water that it is easily injured by rough handling in washing it, or by dropping it on the floor or by forcing water through it under too great head.

In another type of cooler the milk flows from a tank into a perforated distributing trough and over heavily tinned corrugated copper cylinders that are set horizontally in cast-iron supporting racks and vertical water columns from which they may be removed for cleaning. The cylinders are cooled by circulating water or brine through them or by circulating brine through the lower cylinders and water through the upper ones. The water or brine is introduced at the bottom of the water column at one side of the cooler, runs through the bottom cylinder up through the water column at the other side, up it and back through the next cylinder to the first water column, up it into the third cylinder and so on till it passes out of the cooler at the top of the first water column. The cylinders are corrugated to slacken the flow of milk over them and are represented to be very strong. The great advantage of this type of coolers is that they are easily taken apart for cleaning.

Coolers of the continuous-surface type are so built that an unbroken surface on both sides is presented for the milk. Horizontal, round or triangular tubes are united by tinned brass strips carefully soldered to the tubes, making the cooler section a rigid unit. The advantages claimed for the triangular tubes are that they offer a maximum of cooling surface in a little space and that they retard the downward flow of milk over the cooling board. Water or brine is circulated from bottom to top of the board through the system of tubes and the milk is cooled as it

passes over them, down the surface of the board. Sometimes the upper tubes are constructed for cooling with water while the lower ones are made of special ammonia piping for direct-expansion ammonia from a refrigerating machine. By employing direct expansion instead of brine for the final cooling the use of a brine pump, brine tank and coils or brine cooler is obviated and the attendant losses avoided. Screw plugs are provided at both ends of each tube so that the tubes can be thoroughly cleaned, a necessary provision because many waters deposit an incrustation of mineral salts within the tubes, thus impairing their conductivity and so their cooling efficiency.

In the spiral-conical coolers the water enters at the bottom and travels in a spiral course through a small tube around a tinned copper shell or cone and discharges at the top into a cavity beneath the bowl or milk-distributing reservoir, whence it overflows into the outlet pipe. The milk is fed from the bowl into the outer surface of the cone and flows spirally downward over the cold surface of the water tube to a trough at the bottom of the cone whence it is discharged into a receiving can at approximately the temperature of the cooling water. Thus efficiency is gained by the retarding effect of the spiral path of the milk, by bringing the milk in its progress downward in contact with a surface that grows constantly cooler and by the construction of the spiral itself which is such as to spread the milk in a thin film over the maximum of surface in the corrugations toward the bottom.

The advantages claimed for this type of cooler are compactness of design, occupancy of a minimum of floor space per unit of capacity, high cooling efficiency, accessibility for cleaning and a convenient mantle enclosure.

The demand for absolutely enclosed coolers has led to the use of tubular coolers. They are identically the same machines as the tubular heaters that are used for pasteurizing milk but instead of heating the milk in the inner tube or tubes with hot water it is chilled with cold water or brine. The milk in the inner tubes circulates in a direction contrary to that of the water so that the milk in its progress is brought into contact with colder and colder water. These coolers are economical and efficient and besides protect the milk from contamination from the air, prevent the considerable loss that occurs with open coolers from evaporation, may be sterilized under pressure and since they are erected in sectional units may be expanded as the business grows. The drawbacks are that the milk may be contaminated by leakage and that it is difficult to draw off all of the milk at the end of the run. These coolers are in use in some of the largest and best plants.

Many of the above types of coolers can be used as regenerative coolers, by running the cold milk en route to the heaters through the upper sections of the cooler, thereby reducing the temperature of the hot milk from the

heaters, holders and retarders which yields its heat to the cold milk as it flows over these sections and which is finally thoroughly cooled in passing over the lower sections through which cold water or brine runs. These regenerative coolers are economical and are commendable if they receive proper care but they are to be condemned if they are not cleaned thoroughly and regularly for so, the milk in passing them is contaminated.

In choosing a cooler, the quantity of milk to be handled, the temperature to which the milk is to be reduced and the suitability of the machine for the plant should be considered. The capacity of the cooler is largely determined by the area of cooling surface and by construction such that a good circulation of the cooling medium can be maintained. The economy of the circulation must also be considered for where water is scarce or water rates high it may be an important item.

With open coolers the temperature of the room wherein the cooling is done has some effect. Thus in summer when the cooling is being done with cold water it may be necessary to run the milk over the cooler twice to reduce it to approximately the temperature of the water, when in winter once would suffice. It is impracticable to reduce the temperature of milk much below 50°F. in summer without the use of ice or a refrigerating machine. With ice water as the cooling medium, only with difficulty can the milk be cooled much below 40°F. while with brine, the temperature may easily be brought down to 34°F. In cooling milk, the temperature should be taken occasionally with a good thermometer to assure the operator that he is really getting good results.

Many cities now require that open coolers be enclosed with a cover to protect the milk as it flows over the cooler from contamination from the air. This is regarded as of particular consequence in cities, where air is likely to be sooty and dusty and more or less fecally polluted. Of more importance is it to see that the cooler is perfectly clean and sterile before any milk is run over it. Of course the cooler must be thoroughly cleaned after each run but even when this has been properly attended to dust is likely to have settled on the apparatus in the interim between the clean-up and the time for the next run. Hence the need of thorough rinsing and steaming before starting. Bacterial tests have shown that the first milk over the cooler is apt to show a higher count than that which comes over later, the explanation of which is, that the first milk washes off the cooler. In pasteurizing plants the first milk from the machines is likely to have a high bacterial count because they have not settled down to uniform operation; therefore, this first milk should not be run over the cooler to contaminate it, but should be returned for repasteurization.

**Filling the Bottles.**—As soon as milk is cooled it is put into cans and removed to a cold room or it is bottled. Small dairymen fill their bottles by hand with a filling dipper but this is a tedious job and those who can afford something better use an inexpensive machine that enables

them to work about five times as fast. It consists of a tank with four castors that travel on runners at each side of a table wide enough to hold four quart bottles. Four nickel-plated brass valves that are opened and closed by a lever are at one end of the tank which is rolled over the first four bottles, the lever raised and the bottles filled when the tank is pushed over the next four and the operation repeated and so on till all the bottles on the table are filled when they are capped, washed off and put in crates by hand. These machines with their solid metal valves are easily kept clean but the valves in time wear and leak.

Larger dairymen use fillers, the tanks whereof are mounted on a substantial galvanized iron framework and have four to a dozen valves at one or both ends of the tanks and are operated by a hand lever that lifts the crate holding the bottles and presses their mouths against the valves in such a way as to open them and let the milk run in. Milk is usually delivered into the bottles in such a way that it runs down their sides and so foaming is greatly reduced. An air tube in each valve allows the foam and surplus milk to escape from the bottle. When the bottles are filled the lever is lowered, the crate drops and the valves close. If all the bottles in a case are filled at a time, they are capped forthwith but if only four are filled the crate is moved forward and four more bottles filled while the operator caps the full bottles. Such machines as this fill 24 quart bottles a minute. The tanks of these machines are usually of heavily tinned copper with rounded corners and with all seams soldered smoothly. Some of them have a gate so that the milk can be quickly drawn off into cans. In some instances the tanks are of enamelware but on the whole this material cannot be commended because it chips, leaving rough spots and cracks that cannot be properly cleaned. The valves need careful attention. They usually consist of an air tube, stem, sleeve, spring and rubber tip; in some patterns there are nuts and threads besides rubber washers and jackets; consequently, unless the valves are made so that they can be easily taken apart in such a way that each part can be separately cleaned, they are likely to become very foul and contaminate every bottle of milk that is filled. When the valves are of proper design and are kept clean these fillers are excellent but when the valves are patterned so that the rubbers and other parts cannot be detached or when the cleaning of the machine is neglected, they are abominable. Case-moving devices are often attached to the stands.

Within the last four years rotary fillers and cappers have been put on the market and have found acceptance by the largest concerns. The milk is held in a round tank with 10 valves in the bottom. A revolving conveyor carries the bottles in single file beneath the tank when each bottle, in turn, as it arrives in position beneath a valve is automatically raised, thus opening the valve and filling the bottle as it travels in a circular path beneath the tank. When it completes the circuit the bottle is

automatically lowered, the valve closed and the bottle carried by the conveyor beneath an automatic capping machine which caps it as it is traveling on to the place where a man feeds bottles into the conveyor and puts the capped ones into crates. The remarks on valves in the preceding paragraph apply to those in use on the rotary fillers. These machines afford excellent opportunity to inspect the bottles thoroughly and they work fast, filling and capping 38 to 54 quart bottles a minute.

The very largest city milk plants are using automatic power-driven machines that fill and cap six to eight cases of quart bottles a minute.

**Bottle Caps.**—Small dealers cap bottles by hand, somewhat larger ones use hand-capping machines of various sorts and the big ones stationary machines that work very fast. Some of the machines are rented by the dealers, of the manufacturers who for various reasons prefer to retain the ownership of them. Formerly milk bottles with "lightning tops" were in general use. These tops were of tin plate, were wired fast to the bottle and were open and shut by a bail that fitted the neck of the bottle when the cap was closed. The tin top sat flat on top of the rim of the bottle and to prevent leakage a thin pliable, fiber cap was put under it. These tin tops rusted, got out of repair, leaked more or less and interfered with the cleaning of the bottles so that they fell into disuse when the Thatcher Manufacturing Co. brought out the common-sense bottle cap in 1889.

The feature of this bottle is that within the neck is a shoulder or cap-seat that holds the cap, a stiff parffined fiber disc, in place. This cap gave general satisfaction and is in common use. In time the criticism was made that cleanliness and safety demand that the whole mouth of the bottle be covered to protect it from dirt, the drivers' fingers and possible infection. Such caps were soon put on the market and are now supplied to customers that can afford to pay for them. The Crown Cap and Seal Co. in 1910 put out a small-mouthed milk bottle and a special "Dacro" metal cap to fit it. The Standard Cap and Seal Co. later brought out a fiber cap that completely covers the top of the milk bottle to which it is fastened with a wire ring. Each of these companies has its capping machines. Many dealers are putting out their certified milk and cream with a common-sense cap over which is placed a fiber or foil cap that completely covers the bottle.

**Cost of Bottling Milk.**—The cost of bottling milk has been carefully studied by the Dairy Division of the U. S. Department of Agriculture. Figures as to the number of men employed and as to time taken to bottle the milk were obtained from the plant managers and these were checked up by observations in the plants. The figures do not include the packing of the milk in the storage room after the milk was bottled. These four methods of bottling were considered:

1. By large automatic machines that fill and cap the bottles in the case, a full case at a time.
2. Rotary types of fillers and cappers that work automatically but in which the bottles are filled and capped out of their cases and afterwards returned to them.
3. Machines that fill and cap the bottles in the case but that are operated by hand levers instead of automatically. Many of these machines fill a case of pint bottles at one end and a case of quarts at the other.
4. Machines that fill the bottles as in the third method but leave the capping to be done by hand.

The method of both filling and capping by hand was not studied.

In figuring costs, the labor cost was obtained by dividing the total amount expended for labor at all the plants by the total number of bottles that were filled and capped at the same number of plants. The number of bottles filled and capped per man per hour was determined by dividing the total number of bottles filled at all the plants by the total number of men-hours used at the same number of plants. The results are shown in Table 89.

TABLE 89.—THE COMPARATIVE COST OF FILLING MILK BOTTLES AND CAPPING THEM WITH DIFFERENT TYPES OF MACHINES (U. S. DEPARTMENT OF AGRICULTURE)

| Method | Number of plants | Number of cities | Number of bottles filled per hour | Number of bottles filled per man per hour | Labor cost, cents per 100 bottles | Range in cost (cents) |
|---|---|---|---|---|---|---|
| Large automatic | 13 | 4 | 2,771 | 1,233 | 1.6 | 0.9–2.3 |
| Rotary automatic | 17 | 5 | 2,523 | 788 | 2.3 | 1.8–3.4 |
| Non-automatic machine filler | 17 | 5 | 3,665 | 830 | 2.6 | 1.3–5.3 |
| Machine filler, hand capping | 60 | 5 | 1,798 | 553 | 3.4 | 1.7–8.0 |

The table shows that there is considerable variation in labor costs at the different plants using the same types of machinery. The cost of hand capping, on the average, was much higher than machine capping but in some cases the labor cost of capping the bottles by hand was nearly as cheap as by machine. In plants where capping is done by hand the grade of labor employed largely influences the cost; some men can cap bottles nearly as fast as the machine fills them while others cannot. The average cost with the rotary fillers is somewhat less than with the machine fillers and the variation in cost at the different plants is less but the bottom price of machine filling is less than that of rotary filling. In explanation of these facts it is offered that in the plants using the rotary fillers, wages were lower than in plants using the machine fillers; the rotaries were of about the same type and capacity whereas the machine fillers differed greatly in these respects. Had all the stationary fillers been of the most efficient type and had they been run in the best possible manner the costs would have been materially less than shown in the table. Instances were found where the costs with the machine fillers were less than were

shown by any of the rotaries. Many other factors besides the efficiency of the operators and the types of the machines are important elements in the final cost of bottling; thus in some plants dirty and broken bottles delayed the machines while in others the pasteurizers did not deliver the milk fast enough to admit of the fillers being run to capacity.

In all, 107 plants in six cities were studied. It was found that the average number of bottles filled and capped per hour was 3,236, or per man per hour 839 and that the labor cost ranged from 0.9 to 8 cts. per 100 bottles and averaged 2.4 cts. Table 90 shows how the costs varied in the six cities.

Table 90.—Cost of Filling and Capping Milk Bottles in Six Principal Cities of the United States (U. S. Department of Agriculture)

| City | Number of plants | Labor costs in cents | Variations in cents | Number of bottles per man per hour |
|---|---|---|---|---|
| Philadelphia | 25 | 1.8 | 0.9–5.3 | 1,086 |
| New York | 3 | 2.1 | 1.9–3.3 | 964 |
| Pittsburgh | 8 | 2.2 | 1.5–6.3 | 937 |
| Baltimore | 16 | 2.1 | 1.3–6.7 | 739 |
| Boston | 32 | 3.1 | 1.9–8.0 | 725 |
| Washington | 23 | 3.3 | 1.8–5.5 | 571 |

According to these figures the average costs in Boston and Washington were higher than in the other cities, but in Washington a larger proportion of the smaller and less efficient plants were studied, while in Boston 26 of the plants that supplied data were capping by hand at a cost of from 2.1 to 8 cts. per 100 bottles and at an average cost of 4.5 cts. The wages in Boston, too, were higher than in some of the other cities. More automatic machines were used in Philadelphia, New York and Baltimore than in other cities.

The rates at which bottles were handled by the different machines are shown in Table 91.

Table 91.—Rate per Hour and per Man per Hour at which Different Types of Machines Filled and Capped Milk Bottles (U. S. Department of Agriculture)

| Type of machine | Bottles filled and capped per hour | Bottles filled and capped per man per hour |
|---|---|---|
| Large automatic machine, filling and capping a full case at a time | 1,938–8,622 | 966–2,155 |
| Rotary-type filler and capper | 1,350–2,446 | 587–1,040 |
| Machine filler and capper | 750–7,760 | 375–1,552 |
| Hand capping | 350–5,000 | 238–1,066 |

It thus appears that in plants using the same type of machinery there is a wide variation in the amount of work done. It is evident, too, that there is a wider variation in the number of bottles filled per hour than in the number filled per man per hour. This is partly explainable by the fact that in some plants more men than necessary were working on the machines.

Taking into account the overhead charges, interest being figured at 5 per cent. and depreciation of the machinery at 20 per cent., the comparative economy of the different types of machines is shown by the U. S. Department of Agriculture in the graph (Fig. 44).

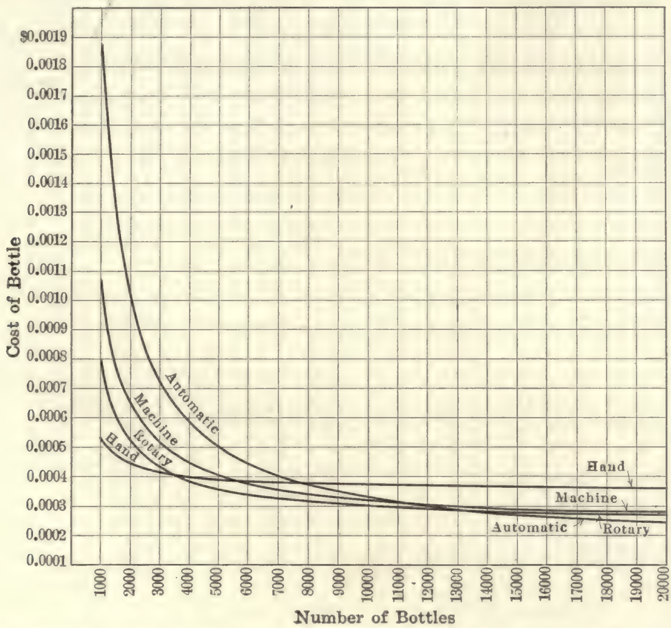



FIG. 44.—Curves showing the labor and overhead costs of filling and capping by different methods at various-sized plants.
(*Milk Plant Letter No.* 41, *Dairy Div., U. S. Dept. of Agriculture.*)

The cost of the automatic fillers was taken at $2,500, of the rotaries at $800, of the machine fillers and cappers at $1,200, and that of the fillers where capping was done by hand at $250. Taking the wage at 20 cts. an hour the average labor costs are computed for each type of machine by dividing this amount by the number of bottles filled and capped per man per hour which shows a cost of 0.016 ct. for the automatic machines, 0.025 ct. for the rotaries, 0.024 ct. for the machine fillers and cappers and 0.036 ct. for the hand capping. Reference to Fig. 44 shows that the curve representing the rotaries intersects the hand-capping curve at 3,400 which indicates that in plants handling less than that number of bottles the hand-capping system would be the more economical. The rotary curve

cuts that representing the automatic machines at 13,000 thus signifying that in plants handling from 3,400 to 13,000 bottles the rotaries are more suitable than the automatic machines. The filling and capping machine curve crosses the hand-capping curve at 5,500, the automatic at 11,000 and the rotary at 27,000 and so indicates the field that the filling and capping machines can profitably occupy. These suppositions cannot be laid down as rules because other factors than those considered affect the costs. In these estimates the cost of power to run the automatic machines was not included and definite figures as to the depreciation of the rotary machines were not available since they have but recently been put into service. The number of machines in use at a plant affects the cost. Thus, with one method of filling and capping, in 10 plants using one machine 766 bottles were handled per man per hour, while the number at five plants using two machines was 904 and at two plants using three machines was but 629. The chief reasons for this are: that often two machines were operated with one man less than twice the number necessary to operate one machine, thus reducing the operating cost; when three machines were used, one was often idle because a great deal of the time not enough milk was handled to keep more than two machines busy.

The number of men used at different plants with each type of machine is shown in Table 92.

TABLE 92.—NUMBER OF MEN USED IN OPERATING DIFFERENT TYPES OF FILLING AND CAPPING MACHINES (U. S. DEPARTMENT OF AGRICULTURE)

| Type | | Number of plants | Average number of men | Variations |
|---|---|---|---|---|
| Large automatic machines | | 12 | 4.3 | 2–7 |
| Rotary type | One machine | 10 | 2.8 | 2–5 |
| | Two machines | 5 | 4.4 | 4–5 |
| | Three machines | 2 | 8.0 | ... |
| Machine filler and capper | | 17 | 4.6 | 3–8 |
| Hand capping | | 60 | 3.0 | 1–6 |

**Bottle Cases.**—As soon as the bottles are filled and capped they are put in the cold room, being sent thither in the larger plants over roller conveyors and in the smaller ones by trucks. The cases or crates that hold the bottles, like other dairy implements, have been improved. The first were entirely of wood and, while they had the advantage of being light, were not easily cleaned and being absorptive soon became smelly; moreover, they wore out quickly. Substituting removable metal partitions for the wooden ones was an improvement but these crates gave place to those made entirely of galvanized iron. They were more durable and more easily kept clean and free from odor but they were much heavier. Furthermore, metal is a good conductor of heat and cold, so

that in summer the ice in which the bottles were packed for delivery melted rapidly, while in winter bottles were likely to freeze in the case and break. Also, the cases became bent out of shape and so would not center the bottles beneath the filling machines. The case that has been finally evolved is a metal one with wire bottoms and partitions; such cases keep their shape, stand hard use, and, as stacked, tend to hold the air motionless around the bottle, so that at all seasons of the year they hold the temperature of the milk for some time, at that at which it is loaded onto the delivery wagons. For shipping certified milk, refrigerator cases are used.

**Bottle Caps.**—Milk-bottle caps, except the metal ones, are made of sulphite fiber impregnated with paraffine. The paraffine is applied hot and should be put on the cap after it is cut and printed in order that the edges as well as the surfaces may be coated. If a good grade of paraffine is not used on the cap, or if it is poorly coated, the cap will impart a noticeable flavor to the milk. The cheap thinly coated caps are not waterproof and so become soft and spongy from absorbed moisture. As the paraffine is hot when applied to the caps they are sterile or nearly so when first made; therefore, the problem is to keep them sterile till used. Some dealers pack them in rolls by machine so that no one handles them, but others are not so careful. Inspectors do well to assure themselves that dairymen are storing their caps in a clean place and are handling them properly.

Common-sense caps are not easily removed from the bottle and so various devices have been brought out to make them so. One firm has a little projection at the edge by which the cap can be lifted. It prevents the cap from setting snugly on the seat and so admits dirt to the bottle. Another cap has a tab affixed to the top by a wire staple which sometimes rusts and discolors the milk. One cap is scored across the middle with the intention of making it possible to raise one side of the cap to pour out the milk and afterward bend the cap back into place. The printing of the cap is important; the design should be attractive and the lettering distinct. The tendency is to make the caps gaudy and to crowd the words together so that they carry no message. By putting a trade mark, or the name of the dairy, or a pat phrase descriptive of the milk on the cap the attention and trade of the public is often caught. The date of bottling is stamped on the cap by dealers in certified milk and by some others. In cities where the milk is graded the grade of the milk is stamped on the cap in large letters.

**Milk Bottles.**—The proper and economical handling of glass bottles is an important element in the city milk business. Ever since Soxhlet's first experiments in sterilizing milk they have been used more or less as containers for it. Pediatrists and those interested in child welfare work, by distributing pasteurized and modified milk in glass bottles somewhat

increased their use, but the idea of the commercial delivery of milk in glass vessels seems to have originated with Alexander Campbell and he was the first to put it into practice. By letter, he states that he began the delivery of milk in glass bottles in the City of Brooklyn, now Brooklyn Borough, New York City, in 1878. The company was operated under the name of the New York Dairy Co., Ltd. and at Monroe, Orange County, N. Y., built the first creamery erected in the United States for the bottling of milk.

The first bottles used were designed by Mr. Campbell after the fashion of beer bottles then in use but had the same size mouth of the milk bottles of today and also "lightning" or tin tops with a paper beneath the tin to prevent leakage. These first bottles were made by Henry S. Putnam of New York City, who at Mr. Campbell's suggestion, for the purpose, modified the machinery he was using in making beer bottles. These bottles cost $21 a gross which is over four times what they would cost now.

In December, 1879, Dr. J. C. Morris of Philadelphia read a paper before the Franklin Institute of that city recounting his success in delivering milk for the preceding 6 months in Cohansey glass jars. He alludes to a jar in use by a Mr. Lester and criticises those in use by Mr. Starr of New York and M. D'Arcy of Paris. Mr. Lester was of Brooklyn and attempted to introduce 1- and 2-qt. jars that had a metal fixture with a rubber gasket and a thumb-screw on top to hold on the glass cover but the device was never a success. Mr. F. R. Starr was also of Brooklyn and established a Jersey herd at his Echo Farm Dairy in Litchfield, Conn. He delivered milk in glass bottles in New York City in the latter part of 1879 or the beginning of 1880. Later his company was absorbed by Mr. Campbell's. Dr. H. S. Thatcher patented a milk bottle in 1883 that was first used by Mr. Wilcox in Ogdensburg, St. Lawrence County, N. Y., in that same year. Milk was first delivered in glass bottles in Boston, Mass., by C. L. Alden, then of the Forest View Farm of Westwood, Mass., but now of the Oak Grove Dairy of Boston, who in the fall of 1884 started bottle service in Hyde Park and in 1883 in West Roxbury, a part of Boston. In 1886 the Whitman Dairy began delivering milk in glass bottles in New York City. In 1889 under a single letters patent the Thatcher Manufacturing Co. patented the "common-sense" milk bottle and the "common-sense" cap.

At first there was vigorous opposition to the use of glass containers. On the one hand, it was an innovation to customers and on the other, dealers predicted that breakage would be so great that the expense would be prohibitive. Mr. Stephen Francesco once told the writer that when he began the use of glass bottles his customers said they did not want milk from the drug store. Nevertheless the bottles slowly won their way. By 1896 approximately 10 per cent. of the milk of Philadelphia was delivered in glass bottles. About 1895 the delivery of milk in glass bottles was

begun in Chicago. In 1896 it was begun in Cincinnati and in 1907 was made compulsory there. Nowadays only small towns have any considerable part of the household deliveries made otherwise than in glass bottles.

Milk bottles should be made of the best clear flint glass and should be properly annealed, otherwise they will be brittle and will fail to stand rough usage and the violent changes in temperature to which they are subjected in washing and sterilizing. They should be free from flaws and the glass should be evenly distributed; irregularities are most likely to occur on the shoulder and at the mouth. Most of the breakage is due to the poor annealing and to uneven distribution of the glass. The cap-seat should be carefully formed and both it and the bottle mouth should be finished smooth that cleaning brushes may not be cut on sharp edges. The bottles of different makers vary somewhat in size but the ½-pt. is approximately 5¼ by 2⅝ in., the pint 7¼ by 3¼ in., and the quart 9⅜ by 3¾ in. It is highly important that the capacity of the bottles be guaranteed; usually it is specified that they shall hold not over 2 cubic centimeters above nor less than 2 cubic centimeters below the indicated capacity. Of course, if the bottles hold more than represented it means loss to the dairymen while if they contain less it means loss to the consumer, and is likely to land the dealer in court, for the milk codes of many cities forbid the use of undersized bottles. The weight of milk bottles varies but in those of good quality the ¼ pt. weighs about 80 lb. per gross, the ½-pt. 125, the pint 180, and the quart 280. There is considerable diversity in the shape of the bottles apart from the special models adopted by some dairymen as advertisements and also as obstacles to their use by others. Manufacturers properly endeavor to fashion bottles so that they will show up the cream well but there are on the market bottles with long narrow necks that give the consumer an entirely false impression of the amount of cream his milk carries. Besides the common-sense bottles there are those with small mouths and no cap-seats, that are for caps that entirely cover the tops. All bottles should be of a shape convenient to clean. Many dairymen use plain bottles but it is better for the owner to have his name or that of the dairy or some distinctive mark moulded into the glass for it enables him to prove his property and should discourage others from using it. In some cities the law forbids one dairyman using another's bottles. Such laws protect the dairyman in the right to his property and are some defense from the danger of his unwittingly coming into possession of and using those of his bottles that other dairymen have placed in houses harboring communicable disease. Discretion should be used in enforcing such laws for much of the delivery of milk is done in the dark and men of honest intention will at times get hold of bottles that do not belong to them. Milk bottles should be colorless but many of them are not so. Some have a purple hue because the glass, which had no color when the bottles were new, contains manganese which the sunlight con-

verts to an oxide that tints the glass. Other glass contains iron which imparts a greenish cast to the glass, making the milk look as though it was skimmed. Some manufacturers purposely give the glass a yellow hue to deceive customers into the belief that they are receiving very rich milk. Colorless bottles clean up brighter than those with a shade of color. Some bottles remain in service long enough to become disfigured with scratches, chipped or nicked and leaky around the mouth. Such bottles should be discarded because they make a bad impression on customers and because a leaky milk bottle is one that can be contaminated. The greatest care should be taken that slivers of glass do not get into the bottles of milk. The breakage and loss of bottles imposes a heavy tax on the milk business.

**Breakage and Misuse of Milk Bottles.**—From replies by 40 dealers the U. S. Department of Agriculture found out that a milk bottle lasts from 6 to 60 trips, the average being 22.5. So with a dealer who delivers 10,000 bottles daily, if the cost was 3½ cts. apiece and if he had to replace them every 22.5 days, the daily expense for bottles would be $15.55 or $5,675.75 a year. In so far as this loss is due to breakage it is unavoidable but a great part of it, perhaps the largest part, should rightfully be charged to the extravagant and dishonest habits of the American people. Bottles instead of being returned to the dealer are thrown into the ash barrel or wilfully broken or are converted by housewives to their own use for such purposes as holding preserves, groceries, etc. Part of the trouble comes from the trade in milk in stores for the purchaser although he may have had to make a deposit for the bottle, never finds it convenient to carry it back or a surly storekeeper may make refunds for the bottles so ungraciously that people are deterred from asking for them. In many of the larger cities, milk-bottle exchanges which are usually operated by dairymen who are the stockholders in the concern have been established to reduce the loss from strayed and stolen bottles. Employees of the exchange collect, carry to its plant and clean the bottles which the several dealers have accumulated that do not belong to them and that pickers at the public dump have saved. Junk dealers sell the bottles they have collected to the exchange and some exchanges purchase bottles from those dealers who go to the trouble and expense of bringing in the stray bottles they have gathered up. Usually nothing is paid for bottles collected at the dealer's plants but bottles brought to the exchange are generally paid for at the rate of ¼ to ½ ct. apiece. The number of bottles recovered from the public dump is astounding; the records of one exchange show that in the city in which it operated, from this source, 1,500,000 bottles were recovered in 3 years. Thus we gaily indulge in the cost of high living.

Besides being depleted by thievery and breakage, a dealer's stock of bottles suffers from abuse. Milk bottles are converted to containers

for every conceivable substance from paints, oil and varnish to dyes, urine samples and anatomical specimens. Of course some such bottles are uncleanable while others are so with difficulty and at added expense. In some cities it is a misdemeanor to fill a bottle with another substance than milk and the code makes it incumbent on the customers to wash milk bottles before returning them to the dealer. To protect the milk dealer in the sole use of his containers a law has recently been enacted in New York State permitting the owner to place his mark upon his milk cans, jars, bottles and register it with the Commissioner of Agriculture. The possession of these containers by another is held presumptive evidence of the violation of the law.

**Paper Bottles.**—The attempt has been made but not successfully to introduce paper bottles. The chief advantages from such bottles would

*Courtesy of Stephen Francisco.*

FIG. 45.—Bottle sterilizer and bottle-washing machine at the Fairfield Dairy, Caldwell, N. J.

come from the fact that they are light and therefore easy to handle, that they would be used but once and, so, would cut out the drudgery and expense of washing and the breakage bill. Their disadvantages are that they are expensive, lack strength and not being transparent prevent the customer from judging of their cleanliness and of that of their contents and from observing the cream line.

**Bottle Washing.**—Bottles are washed by hand in the small dairies and by machines in the larger ones. In hand washing the bottle is merely swabbed out with a brush and the bottles rinsed in a tank; in somewhat larger dairies the bottles are washed by revolving, power-driven brushes and rinsed in a tank or quite as often, over small jet machines. The largest dairies use big automatic bottle washers that wash the bottles in their cases. The machines are made by several manufacturers and of course, differ from one another in construction but in general they have a soaking tank or compartment, a washing compartment where the bottles are cleaned by revolving brushes or more often by jets of hot water shot into the bottle and case under high pressure, a rinsing compartment where jets of hotter water play on the bottles and finally a sterilizing compartment where the bottles are put into boiling water, or have either jets of very hot water or of steam played on them. These machines wash all but the exceedingly dirty "alley" bottles clean, and are no doubt capable of killing all of the non-spore-bearing germs if run at the temperature directed by their makers but if dairymen economize by cutting down the heat, these washers do not sterilize the bottles. Inspectors should satisfy themselves that the machines are operated properly. A cold washroom full of vapor is no guarantee that the sterilization that is being attempted by steam is effective.

**Cost of Bottle Washing.**—The Dairy Division of the U. S. Department of Agriculture has made a study of the cost of washing bottles. Data

TABLE 93.—COST OF WASHING MILK BOTTLES IN 91 PLANTS BY AUTOMATIC, BY BRUSH MACHINES AND BY HAND (U. S. DEPARTMENT OF AGRICULTURE)

| Method of washing | Number of plants | Number of cities | Labor cost in cents per 100 bottles | Range of cost, cents | Number of bottles washed per man per hour | Number of bottles washed per hour |
|---|---|---|---|---|---|---|
| Automatic machines | 40 | 5 | 1.9 | 0.7– 4.2 | 1,044 | 4,196 |
| Brush machines | 43 | 5 | 4.9 | 2.1– 7.5 | 342 | 1,061 |
| Hand | 8 | 3 | 9.7 | 6.4–13.2 | 199 | 433 |

TABLE 94.—COMPARISON OF THE COST OF WASHING BOTTLES IN FIVE CITIES OF THE UNITED STATES (U. S. DEPARTMENT OF AGRICULTURE)

| City | Number of plants | Labor cost in cents per 100 bottles | Range of cost, cents | Number of bottles washed per man per hour |
|---|---|---|---|---|
| Philadelphia, Pa. | 20 | 1.8 | 1.0– 3.0 | 1,115 |
| Baltimore, Md. | 11 | 1.5 | 0.7– 6.0 | 1,054 |
| Boston, Mass. | 32 | 3.1 | 1.3–13.2 | 691 |
| Pittsburgh, Pa. | 9 | 3.2 | 2.7– 7.5 | 610 |
| Washington, D. C. | 19 | 4.3 | 1.7–11.1 | 377 |

was collected in 91 milk plants in Boston, Baltimore, Philadelphia, Pittsburgh, and Washington. Table 93 summarizes the cost of washing bottles at these plants and Table 94 shows how the cost of washing bottles in the five cities compares, all three types of washing being used.

In Table 94 the results were obtained by dividing the total cost of labor at all of the plants in each city by the whole number of bottles washed in that city. The high costs in some of the large plants in Washington increased the average cost.

Table 95 summarizes the costs for all the plants studied in the five cities and Table 96 compares the bottles washed per hour and per man per hour by the three methods.

TABLE 95.—COST OF WASHING BOTTLES IN 91 PLANTS IN FIVE CITIES OF THE UNITED STATES (U. S. DEPARTMENT OF AGRICULTURE)

| No. of plants | Cost in cents per 100 bottles | Range of cost, cents | No. of bottles washed per man per hour | No. of bottles washed per hour |
|---|---|---|---|---|
| 91 | 2.4 | 0.8–13.2 | 809 | 2,870 |

TABLE 96.—COMPARISON OF THE NUMBER OF BOTTLES WASHED BY THREE DIFFERENT METHODS (U. S. DEPARTMENT OF AGRICULTURE)

| Method | No. of bottles washed per hour | No. of bottles washed per man per hour |
|---|---|---|
| Hand | 180–950 | 135–266 |
| Brush machines | 233–3,840 | 200–800 |
| Automatic machines | 1,296–7,916 | 525–2,000 |

Table 96 shows a wide variation in efficiency even when the same method of washing is used. This is partly accounted for by various factors such as machines of the same type being more serviceable and of larger capacity than others, operators being delayed by breakdowns, broken bottles, lack of steam, etc., but the lower figures, as a whole, show poor work.

Table 97 shows the number of men employed with the different methods at the several plants studied.

TABLE 97.—NUMBER OF MEN EMPLOYED ON DIFFERENT TYPES OF BOTTLE-WASHING MACHINES (U. S. DEPARTMENT OF AGRICULTURE)

| Type | No. of plants | Average No. of men used | Range in No. of men |
|---|---|---|---|
| Automatic machines | 40 | 3.6 | 2–8 |
| Brush machines | 43 | 2.8 | 1–7 |
| Hand | 8 | 2.1 | 1–5 |

From the labor costs and the cost of machinery used, the relative economy of the different methods of washing bottles for plants of different sizes can be determined. The average cost of brush machines was $175 and of automatic washers was $1,500 with a 20 per cent. depreciation and with 5 per cent. interest on the investment; the overhead expense at these prices is 12 cts. per day for the brush machine and $1.03 for the automatic. In hand washing the overhead expense would be the upkeep

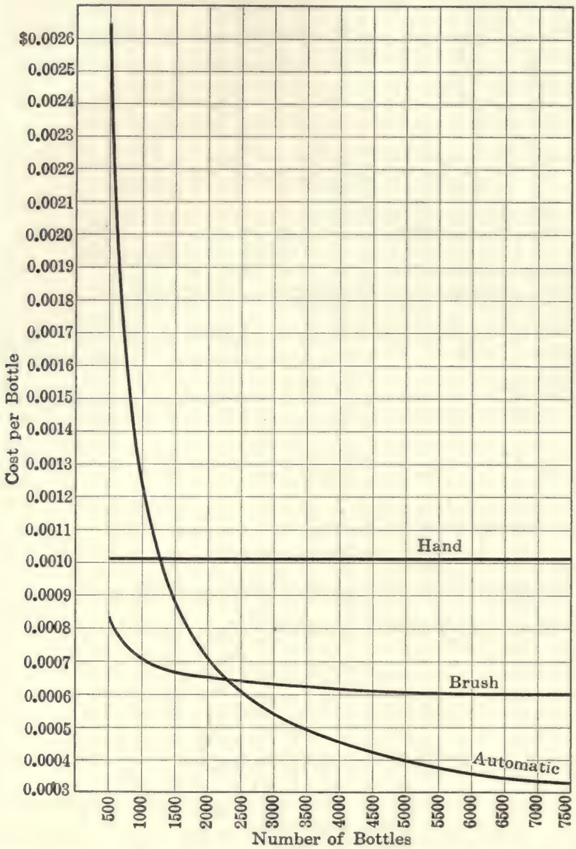



FIG. 46.—Curves showing the labor and overhead costs of washing bottles by different methods at plants of various sizes.
*(Milk Plant Letter No. 18, Dairy Div., U. S. Dept. of Agriculture.)*

of the floor space and is not figured. Taking the wage at 20 cts. an hour the labor cost with each type is determined by dividing this by the number of bottles washed per man per hour in each type which gives 0.00019, 0.000585 and 0.00101 ct. for hand, brush and automatic washing respectively. With these overhead expenses as an average and this labor cost for each method the graph (Fig. 46) has been constructed. Hand washing is represented by a straight line since the labor cost remains the same

for any sized plant, no equipment is required and the overhead expense is not considered. It appears that the line representing brush washing is uniformly below that for hand washing while the automatic machine is shown to be cheaper than the latter when 1,200 to 1,300 bottles are washed. The lines representing the automatic and the brush-washing machines intersect at 2,300 bottles indicating that with this number of bottles to wash a dealer would do well to install an automatic machine. The Division points out that comparatively few plants were covered and that the amount of power required has not been included in calculating these costs.

**Storage and Inspection of Bottles.**—In small dairies the washed bottles are kept in the milk-handling room. In the larger dairies the bottles are carried on roller conveyors to the storage room. On the way the cases are carefully inspected for chipped and cracked bottles and a sharp watch is kept for such bottles while the empty bottles are being fed into the filling machine.

**Sterilization of Bottles by Steam.**—After bottles are washed they should be sterilized. In plants large enough to afford a stationary boiler the sterilization is done either in streaming steam or steam under pressure, usually 15 lb. for 15 min. being used. When the steaming is done conscientiously it is efficacious but if done in a haphazard way the bottles may be merely warmed up to the incubating temperature and conditions created for bacterial multiplication.

**Sterilization of Utensils, Etc., with Washing Powders.**—The great majority of dairymen cannot afford steam. So it would be advantageous if a cheap safe disinfectant were available for their use. Doane defined a good creamery disinfectant as one that is odorless, tasteless, non-poisonous, cheap and in small quantities is reasonably effective, and that is germicidal to non-spore-bearing forms. He quotes the work of others on the value of soaps as disinfectants and tested the disinfecting power of several washing powders.

Experiments with one or two soaps indicated that in 5 per cent. solution they are effective germicides. To the free alkali, the disinfecting power of the soap is partly attributable but he is inclined to believe that either the glycerin or salts of the fatty acids of the soap have bactericidal properties. Since the appearance of this paper, the disinfecting power of soaps has been questioned; Pease has recently stated that it is considerable when the water is hot.

While the composition of the washing powders with which Doane experimented is a trade secret analysis showed that they were 80 per cent. soap and 20 per cent. free alkali—the latter being caustic soda. In experimenting, his procedure was to make a dilution 0.1 to 0.5 c.c. of milk in 5 c.c. of sterilized water. Then for the controls a measured quantity of the dilution was put in another 5 c.c. of sterilized water and measured

quantities of this were added to each of two tubes of lactose agar and plated. For the test sample the same quantity of the dilution was put into 5 c.c. of a solution of a weighed quantity of washing powder and water, either at room temperature or 130°F., and added to the lactose agar at stated intervals. At first 1 gram of powder to 300 of water was used but this was found to be too weak and so it was used in the proportion of 1 gram to 150 of water which is at the rate of 1 lb. of powder to a little more than 17 gal. of water. The powders cost 5 to 6 cts. a pound. Savogdram, Gold Dust and Pearline were tested and also sal soda or washing soda, baking soda and caustic soda. The results indicate that Savogdram, Gold Dust, Pearline and sal soda, in the proportion of 1 part by weight to 150 parts of water at the temperature of 130°F. and with an exposure of 10 min. exert a notable disinfecting action. However, the objection is made to sal soda that it deteriorates so rapidly that it can be kept in stock only in small quantities. In contact with the air it loses its water of crystallization and crumbles to a white powder that actually interferes with washing. Baking soda which is often recommended for cleaning nursing bottles has none of the properties of a soap and no disinfecting action when used in the proportion of 1 part to 150 of water and only a slight one in the proportion of 1 to 8. It is suggested that by neutralizing the sour smell in the bottle it deceives one into the belief that it is a cleaner. The experiments with caustic soda indicate that there was something besides the 20 per cent. of free alkali in the washing powders that in a marked degree increased their antiseptic properties.

Wyandotte and tri-sodium phosphate are used in large quantities as bottle cleansers but neither of these were tested in the experiments.

Doane advises that in creameries washing powders be used in a hot solution of 1 lb. to 25 gal. The floors should first be washed with hot water and then with the hot solution which should be allowed to dry off, for the longer it remains the more effectively will it kill germs and check odors. Tinware should be rinsed with cool or tepid water, then washed in hot water after which the solution of washing powder should be added and the utensil shaken to make sure that the solution touches every part. So the whole stock should be treated and finally after 5 or 10 min. should be rinsed with clean water.

Washing powders deteriorate; so they should not be purchased in large quantities.

**Sterilization of Bottles with Bleaching Powder.**—Whittaker and Mohler suggest the sterilization of milk bottles by submerging them for 20 min. in a solution of calcium hypochlorite or bleaching powder containing not over 10 parts per million of available chlorine or roughly 1 oz. of powder to 100 gal. of water. In their experiments they obtained a total average bacterial efficiency of over 99.9 per cent. An examination

of the bacterial plates of two dairies showed that over 95 per cent. of the surviving organisms were spore bearers. The use of hypochlorite must be confined to the sterilization of bottles for it attacks tinware rapidly. Bottles that have been put in hypochlorite or bleach, as it is called, should be carefully rinsed lest its unpleasant odor may cling to the bottles and cause complaint on the part of customers. How generally chloride of lime is used by dairymen the writer does not know but is of the opinion that it is comparatively little. It is not at all impossible that in the future it may be employed more commonly. It kills the non-spore-bearing germs, which includes most of the disease germs; consequently, when health officers and others have to disinfect bottles that have been exposed to infection, and no steam is available to do it with the "bleach" is the very thing for the purpose, but the bottles should be rinsed first, because the bleach will exhaust its strength on milk and other organic matter and so lose some of its germicidal power. Also, the bleaching powder must be fresh because it deteriorates rapidly on exposure to air. During the prevalence of foot-and-mouth disease in Illinois in 1915 some of the certified dairies regularly immersed their milk bottles and crates in a solution of chloride of lime.

**Milk Cans.**—The milk cans are important milk utensils. They have to be strong because they are subjected to merciless treatment. They are made of steel and are heavily plated. All joints are flooded with solder that there may be no crannies where milk curd may accumulate and germs multiply. The weak points of the can are the neck, the bottom and the breast. The neck is usually double and should be reinforced strongly where it joins the can for great strain comes at this point from piling the cans on top of one another, people standing on the tops, etc. The breast is usually protected by a heavy steel hoop that is soldered onto the outside of the can and the bottom is protected in the same way or by a piece of sheet steel rolled over the body in such a way as to make a projecting bottom rim. The body of the can is stamped out of a single piece of steel. The covers are of two principal types, the slip cover which is the commoner and the umbrella cover which is being adopted because it overhangs the can and protects the top from dirt. Covers are usually made of seamless drawn steel and should be smooth and strong. In New England the 8½- to 10-qt. cans have a handle attached to the neck and breast; the necks are 3½ in. in diameter and are sometimes closed with a tin cover but almost always a stopple or bung of maple or other hardwood is used. These stoppers are absorptive and for that reason are objectionable on sanitary grounds. The handles of both covers and cans should be rounded and of ample size. As the cans are constantly traveling they should be marked with the owner's name or his trade mark. The most permanent way of marking cans is to emboss the name with a die on the breast, cylinder or neck; less expensively, letters or a name

plate may be soldered onto the can. One of the problems in shipping milk is to make sure that the milk is not tampered with in transit. So various devices have been patented for locking the cans. The lead seal is most commonly used.

The condition of the cans must be good; battered and dented cans are objected to because they give short measure and also because they are impossible to clean and are, therefore, insanitary. The shipping of cream in rusty cans is the cause of the fishy odor in butter. Boards of health confiscate rusty and battered cans because of their highly insanitary character.

The washing of cans in many dairies is very carelessly done. This is a great mistake for if they are not thoroughly clean and sterile they will seed the milk that is put in them with germs. It is particularly bad to leave a little milky water in the can for it is a splendid culture medium for germs. When cans are cleansed they should be scrubbed outside and in, thoroughly rinsed, and then sterilized with steam, after this they should be dried out with a hot air blast or inverted and dried in the air, after which the cover should be put on. Swabbing out a can with a sour rag as it is often done is not washing it. In the milk plant and on the farm the cans should be kept inverted or covered to keep out rats, mice and flies.

**Item of Shrinkage in City Milk Plants.**—The shrinkage and waste of milk in city milk plants is an item to be considered. One of the large dealers of the country who makes a determined effort to keep this loss at minimum gives the figures in Table 98 showing the percentage of loss at his plant month by month for 2½ years.

Table 98.—Percentage of Shrinkage in the Total Volume of Milk in Passing Through a Large City Milk Plant

| Year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1911 | 2.10 | 2.42 | 2.12 | 2.44 | 2.41 | 2.62 | 3.91 | 3.56 | 3.28 | 3.29 | 3.32 | 3.22 |
| 1912 | 2.44 | 2.58 | 2.21 | 2.57 | 2.11 | 2.27 | 2.79 | 2.56 | 2.82 | 3.07 | 3.01 | 3.05 |
| 1913 | 2.73 | 2.65 | 2.45 | 2.32 | 2.18 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Average.. | 2.42 | 2.55 | 2.26 | 2.44 | 2.23 | 2.44 | 3.35 | 3.06 | 3.05 | 3.18 | 3.16 | 3.14 |

The Dairy Division of the U. S. Department of Agriculture obtained estimates of the daily losses of milk in city milk plants from 41 dealers and found that they ran from 0.5 to 4 per cent., averaging 2.15. A dealer who handles 5,000 gal. of milk a day and loses 2.15 per cent. of it, in the course of a year with milk at 30 cts. a gallon, would lose $11,771.25, a very tidy sum. The Division points out that there is a certain amount of unavoidable loss in transferring milk from cans to bottles and in the

processes of clarifying and pasteurizing but that most of the loss is properly placed under the other heads in the following list of losses and should be eliminated:

1. Leaky cans.
2. Dented or battered cans.
3. Partially filled cans.
4. Careless handling of the cans in transferring them from the cars and in dumping them.
5. Insufficient draining of the cans.
6. Leaky or battered apparatus.
7. Fillers in disrepair—leaky valves.
8. Losses at the filler from poorly adjusted valves, careless handling, breakage of bottles, etc.
9. Loss arising from failure to remove all the milk from pasteurizers, pipes, pumps, tanks and other apparatus.
10. Mechanical losses, and loss by evaporation in clarifying, pasteurizing and cooling.

**Homogenized Milk.**—Many city milk dealers, besides selling whole milk and cream, put out homogenized milk and milk beverages. The former is a comparatively new product. According to Baldwin the patents on the first machine were taken out by Gaulin in 1892, but the present successful type was not perfected till 1902. Milk and other emulsions are homogenized by forcing them through very fine openings under pressure of about 3,000 lb. per square inch with the result that the fat globules are broken up into fragments so minute that they cannot agglutinate and cannot rise because, as Lindet has shown, the ascending force of the fat globules in milk and cream is proportional to the cubes of their radii and so when the diameters become less than 1 or 2 microns milk will not cream.

Homogenized cream can neither be whipped nor churned to butter. In this country two machines are in common use for homogenizing milk, the Gaulin and the Progress homogenizers. In the Gaulin machine the milk is forced by single-acting pumps against an agate valve which presses against a ground seat and forces the milk between the ground surfaces of the valve and seat. In the Progress machine the milk is forced by single-acting pumps between a series of discs with ground surfaces. The discs are placed flat on one another, are held together by a rod running through the center and are enclosed in a cylinder. The discs are pressed against each other by a heavy spiral screw which regulates the pressure to which milk is subject. The milk passes from the center to the periphery of the discs of which there are two types. One of them has very fine grooves through which the milk shoots against a hard shoulder and the other has smooth surfaces with narrow area of contact. Owing to the high pressure under which the machines work, considerable skill is needed to oper-

ate them for if it is not done correctly the homogenized milk will have a "burnt" or "metallic" flavor readily detectable by those who are familiar with it.

Baldwin made two sets of measurements of the fat globules in samples of homogenized cream from two different machines working under pressures of from 700 to 4,000 lb. per square inch. He found that in general the degree of homogenization is increased with the pressure and in one of the machines the destruction of fat globules is so great that most of them lose their spherical form and under a 2-mm. objective look like a fine amorphous precipitate. The diameter of the majority of fat globules Baldwin found to be of 0.005 to 0.006 mm. and of the homogenized globules 0.001 to 0.002 mm. The experiments are given in Table 99.

Table 99.—Relative Number of Fat Globules of Various Sizes in Natural Cream and in Cream Homogenized under Various Pressures (Baldwin)

Diameters in millimeters

| | 0.009 to 0.007 | 0.007 to 0.006 | 0.006 to 0.005 | 0.005 to 0.004 | 0.004 to 0.003 | 0.003 to 0.002 | 0.002 to 0.001 | 0.001 to 0.0005 |
|---|---|---|---|---|---|---|---|---|
| Natural cream | Few | Many | Most | Few | Few | Very few | | |
| Homogenized cream | | | | | | | | |
| Machine No. 1. | | | | | | | | |
| 1,000 lb. | ..... | ..... | Very few | Few | Many | Many | Most | Very few |
| 2,000 lb. | ..... | ..... | ..... | Very few | Few | Many | Most | Very few |
| 4,000 lb. | ..... | ..... | ..... | ..... | Few | Many | Most | Very few |
| Machine No. 2. | | | | | | | | |
| 700 lb. | ..... | ..... | ..... | Very Few | Many | Many | Most | Very few |
| 2,000 lb. | ..... | ..... | ..... | ..... | ..... | ..... | Many | Mostly granular |
| 3,500 lb. | ..... | ..... | ..... | ..... | Very few | Few | Many | Mostly granular |

Homogenized milk is used to some extent for infant feeding and for invalids, and mixtures are used, too, that are made by homogenizing olive oil or other fats in place of the butterfat. Some milk dealers put out an homogenized milk or cream that is popular with their customers and takes the place of coffee cream. A drawback to this product is that it sometimes curdles when coffee is poured onto it. If ice-cream manufacturers did not purchase and store large quantities of butter fat when milk is plenty they would not have it for making ice cream at seasons when little is to be had. They have two ways of meeting the situation: one of them is to freeze large quantities of sweet cream and hold it in cold storage

till it is needed, when it is melted for use, and the other is to hold large quantities of sweet butter in cold storage and homogenize it with skim-milk or milk powder as it is needed. The success of homogenizing for these purposes has led to the introduction of machines called emulsors which emulsify cream products in such a way that the fat is not broken up enough to prevent cream and butter being again separated. Ice cream made from homogenized cream is believed by some to be superior because of its smooth consistency.

One milk dealer is reported to have lost much of his trade by tricking his customers by separating his milk and homogenizing the cream separately and then returning it to the milk where it formed a more bulky cream than before, which deception cost him heavily when at last it was discovered. Also, it is possible to homogenize other fats than butter-fats with skim-milk and so to deceive the public. Thus while homogenizing may be misused by the unscrupulous, in the hands of honest men it has its proper applications.

**Milk Beverages.**—Much of the skim-milk in milk plants is made into milk beverages which are used in increasingly large quantities by the public.

**Recovery and Use of Casein.**—In the smaller milk plants there may be considerable loss from skim-milk for often the only way of disposing of it is to sell it to the farmers. In other plants the casein is recovered in the following manner; 2,500 lb. of skim-milk are heated to 120°F. and 11.5 lb. of sulfuric acid of a specific gravity 1.83 are added, care being taken to dilute the acid well before putting in the skim-milk, otherwise it will burn and discolor the curd. As the acid is added the skim-milk is stirred. If too little acid is added a soft curd, which does not press well, results. The curd is pressed, after which it is ground and then dried at 145°F. If the temperature rises to 150°F. the curd burns. The dried curd is then shipped to large manufacturers of casein products.

**Care of Milk Plant and Creamery Wastes.**—The care of the wastes of a city milk plant or of a creamery is important. If they are permitted to flow out on the ground, a nuisance results. Whenever it is possible connections should be made to the public sewer. Where this cannot be done other methods of sewage disposal must be adopted. In some cases the sewage may be disposed of by dilution, that is, by discharging it into a running stream. Sometimes local or State laws prohibit such a practice and sometimes the volume of the stream is not great enough to dilute the creamery effluent to such a degree that no nuisance will result. This is the more likely to be the case from the fact that the volume of waste is likely to be largest when that of the stream is smallest. In such cases recourse must be had to sewage treatment.

Two methods have been found applicable to creamery wastes, viz.:

(1) digestion in the septic tank followed by filtration; and (2) treatment in the Imhoff tank. Creamery sewage differs from ordinary sewage in that it contains considerable fat and much casein, which make it prone to clog, and lactic acid which in tanks has a tendency to restrain bacterial decomposition. Besides the butterfat it carries also the machinery oil so that it is well to interpose a grease trap on the pipe line between the plant and tank to catch this fat and also lumps of casein, that do not decompose easily. Where a tank is used, waste acid should be kept out of the sewage because it interferes with bacterial decomposition. The clear water that is used for cooling should also be kept out of the sewage partly because it is cold and, therefore, tends to retard bacterial action but chiefly because it greatly increases the volume of the sewage to be handled and so increases the cost of treatment by making larger works necessary.

The tanks should be large enough to hold the sewage for 3 days and should be provided with a dosing chamber for continuous discharge onto the filter beds interferes with their action. Sometimes the addition in the dosing chamber of chloride of lime at the rate of 1 to 5 lb. per 1,000 gal. is advisable an hour before running the tank effluent onto the filter beds for in this way foul odors are checked.

The filter beds are built of properly selected sand or crushed stone that is underdrained with open vitrified tile. The surfaces should be kept clean and when they become clogged the beds should be raked lightly. In time the upper surface of the sand has to be removed and replaced. The effluent of the filter beds may be disposed of by running it into a stream, or more economically by subsurface irrigation through open-joint tile or by surface irrigation.

The Imhoff tank is constructed and operated as such tanks usually are and needs no special description. However, it should be noted that owing to the development of acid fermentation it may be necessary to add a small quantity of lime to the waste in the tank. If a highly purified effluent is desired it may be advisable to filter the effluent from the Imhoff tank. Otherwise, it can be discharged into a stream or onto land.

**Holding Milk at Low Temperature.**—Dairymen who operate their routes from the farm generally hold the milk till it is wanted for delivery in tanks of spring or of well water. Such water as it issues from the ground usually has a temperature of between 50° and 55°F. so that ordinarily by its use milk cannot be cooled to as low a temperature as desirable, viz., 45°F. Somewhat better results can be obtained with ice water. Small milk plants use ice bunkers to cool their storage rooms and larger ones use the gravity brine system. The big plants use mechanical refrigeration generally with ammonia as the refrigerant. Refrigeration is a highly important part of the milk business but it cannot be properly developed in detail here. Those readers who are interested in the subject are referred to Bowen's bulletin on the subject.

**Refrigeration in the Home.**—Milk dealers are interested not only in the refrigeration that their producers and they themselves use but they are also in that in the homes of their customers for the best milk will spoil soon after delivery unless it is kept cold.

Williams made an extensive investigation of the facilities for keeping perishable foods in the homes of Rochester, N. Y., and found that they were generally preserved in a cool place in the cellar, in living rooms or in ice boxes. He came to the conclusion that in one-half of the homes the cellar and pantry were relied on to preserve food and that in three-quarters of the homes ice was taken for only a few weeks in mid-summer. He studied 243 refrigerators and found that only 103 maintained a temperature of less than 50°F.; the other 143 had higher temperatures and were worthless for preserving food. The better refrigerators were in the better homes but in 45 per cent. of the homes of this class the refrigerators showed temperatures of over 50° while in the homes of the working people over 70 per cent. did.

**Economy in the Use of Steam.**—One of the items of expense in the city milk business is the cost of cleaning and sterilizing the utensils and with the larger dealers this is augmented by the necessity of generating power to run separators, clarifiers, filling and capping machines, pumps and pasteurizing machinery. The very smallest dealers get on by heating the water they need over stoves but this is tedious work, consequently only a very few use enough water. So, boards of health are taking the ground that a gas heater or a steam boiler must be used. Indeed, all dairymen who are conducting a business of any considerable size have steam boilers and the larger dealers have big power plants with steam boilers, steam engines, gas engines and dynamos. It is apparent that the chances of incurring loss in this part of the business are good. Waste of fuel, lubricants and other supplies is bound to occur unless guarded against. Incompetent operation of the plant is likely to cause rapid depreciation of the machinery and excessive repair bills. Losses occur, too, from poor layout of the plant and from failure to utilize all the heat or power in the steam.

**Retail Delivery of Milk.**—The delivery of milk has undergone a great change within a few years. Prior to the introduction of the glass bottle the dealer carried his milk in bulk in large tin cans on the wagon and appeared at the door with the can over his arm and a quart measure in his hand ready to deliver the amount of milk the customer needed for the day. At a little later period in place of the dozen or two cans of milk, there were placed in the front of the wagon, two huge ones with stirrers and faucets out of which the milk was drawn into a measure. There were three principal objections to the delivery of milk in bulk, namely: that through carelessness or design one customer got richer milk than another; that the milk was seriously contaminated from repeated ex-

posure to the dust of the street and the dirty hands of the driver; and that the mode of delivery was time-consuming and therefore expensive.

The contamination of milk in the course of delivery was studied by Way in Cleveland, Ohio, in November and December, 1906. He found that in the average of 40 samples from seven different dealers the "dip" milk contained an average of 37 per cent. more bacteria than the bottled milk; that the "dip" milk contained the greater number of bacteria in 77.5 per cent. of the samples; that 16 samples of the "dip" milk were over 50 per cent. and eight over 300 per cent. higher than the corresponding bottled sample; that the bottled milk contained the greater number of bacteria in 22.5 per cent. of the samples and of these but three were over 50 per cent. higher than the "dip," the highest of them being 237.6 per cent.

Dry weather with a stiff breeze during delivery usually resulted in an increase of several hundred per cent. in the bacterial content of the "dip" milk over that same milk served in bottles.

In small communities where the production and sale of milk is virtually uncontrolled, the delivery of milk by the dip method is usual. Despite the fact that delivery of milk in the bottle is now regarded as the best way to handle it, the method was slow in winning public approval. Customers were in the habit of getting their milk from cans and were loth to change. Both dealers and customers looked on the delivery of milk in glass as likely to be prohibitively expensive and the tidy housewife was not inclined to admit to her home glassware that circulated promiscuously about the city. Moreover, the milk bottle in time proved itself to be an occasional vehicle of contagion. However, in this respect it was found on the whole to be no more dangerous than the dip method of delivery and it was found that the danger from infected bottles could be very successfully controlled by a provision in the health code requiring the daily sterilization of milk bottles. Slowly and surely the bottles forced out the dip method of delivery. They have the advantages that the dealer can show the customers the cream line and that there is no sediment in the milk; they make an attractive package and are convenient to handle both on the route and in the homes.

In our large cities the delivery of dip milk has almost ceased and in many of them is forbidden by law. However, the delivery of milk in bulk in cans, to hospitals, school lunch rooms, various public institutions and to stores is often permitted. This is usually a concession to the convenience of the user or to enable him to get milk more cheaply and should be granted only with the understanding that conditions attending the delivery and storage of milk will receive frequent and strict inspection.

In places where the milk is delivered in bottles the filling of bottles on the route should be forbidden. It is impossible to fill them on the streets in a cleanly manner and without exposing the milk to contamina-

tion from dust. Sometimes delivery boys will fill bottles by thrusting the bottles down into a can of milk thereby contaminating all the milk in the can and filling the bottles with dirty milk.

Progressive dealers give a great deal of thought to the delivery of milk for if it is not watched it is likely to become unduly expensive while close attention to the service is apt to suggest ways in which expense may be cut and sales increased.

The delivery outfit is under daily observation by a critical public, consequently it is worth while to keep it spick and span. The horse should be well-groomed; the harness should be clean and oiled with the trimmings well-polished; the wagon should be kept well-painted and washed. The driver should be clean, obliging and tactful. A uniform adds to his appearance if it is kept in repair and clean. The advertising value of a well-kept delivery outfit is well-known. A dirty one is *prima facie* evidence of an insanitary supply. A jaded half-starved horse tells of the lack of prosperity of the owner, perhaps of his willingness to take advantage of others. An attractive wagon every moment it is on the road extends a fetching invitation to do business with the owner. The color of the wagon may well be distinctive but garish colors should be avoided. The trade mark or some phrase descriptive of the dairy or of the goods may well be printed on the wagon but the lettering should be plain and simple. The appearance of many delivery wagons is spoiled by carrying too much lettering and by that which is poorly done. A clean good-mannered deliveryman will get trade where a dirty, smelly, uncouth fellow will fail. The public regards the man on the wagon as merely a driver but his employers look on him as a salesman. It is his ability to get trade and not that to pilot a wagon that makes him valuable. He is often paid a commission for new business or given a bonus as a reward for his contribution to the general prosperity of the company. Some of the larger companies give their deliverymen lessons in salesmanship and see to it that they are instructed on such matters as the chemical composition of milk, its food value, the bacterial count, pasteurization, the methods of handling milk in the plant and on the way it should be cared for in the home. It should be the object of the dealer to secure certain and regular delivery of the milk and to cater to the needs and wishes of his customers. Particular pains should be taken that new customers are not overlooked or special orders forgotten. On certain holidays such as Christmas or Easter it may be customary for the patrons to take more cream and by calling attention to the approach of the day the company can often take orders which it would have to refuse were they not booked ahead of time. The good will of patrons is often won by seeing to it that the milk is delivered at some particular spot where it is wanted instead of decorating the front door step or some other equally prominent place with the bottles. Frequently a suggestion that a covered recep-

tacle for the milk will protect it from the heat, dogs, cats and flies and perhaps from being stolen is a good stroke for both the company and the consumer. Some delivery men get disliked by cutting across lawns and flower beds. A noisy driver is an infernal nuisance. In the modern


FIG. 47.—Delivery wagon in which the driver mounts over the wheel.

city, so many keep late hours and there are so many night workers that a driver who shouts at his horse and rattles the bottles about becomes deservedly unpopular. Some towns like Brookline, Mass., have made a


FIG. 48.—Delivery wagon with the door between the wheels.

special effort to abate the noise attendant on early morning deliveries and among other things have had rubber-tired wagons adopted.

Milk is not ordinarily delivered with a team; when one is used the route is generally a long one or the milk is hauled into the city from a dairy farm nearby. Ordinarily deliveries are made in a one-horse wagon.

TABLE 100.—DATA ON HORSE-VEHICLE OPERATION (THOMSON)

| | General information | | | | | | | | Performance | | | | Operation and maintenance, dollars per annum | | | | | | | Overhead charges, dollars per annum | | | | | Total dollars per annum | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | Per horse | | | | Per wagon | | | Per horse | | Per wagon | | | | |
| Business | Number of one-horse wagons | Number of two-horse wagons | Average number of horses | Per cent. of extra horses | First cost of one-horse wagons | First cost of two-horse wagons | Average price paid for horses | First cost per harness | Miles traveled per wagon | Trips per wagon per day | Deliveries per wagon per load | Pounds hauled per wagon per day | Shoeing | Veterinary | Feed | Stable rent, stable labor and general expenses | Wagon repair and painting | Harness repair | Driver | Interest and amortization | Interest and amortization, single wagon | Interest and amortization, double wagon | Operation per horse | Maintenance per wagon | Operation per horse | Maintenance per wagon |
| Milk | 1,234 | 237 | 1,983 | 16 | $225 | $225 | $225 | $25 | 8 | .. | 225 | 2,000 | $21 | $3 | $180 | $50 | $100 | $5 | $780 | $34 | $38 | $38 | $254 | $105 | 254 | 105 |
| Milk | 62 | 8 | 86 | 10 | 275 | 500 | 250 | 45 | 20 | 1 | 150 | 1,800 | 20 | 3 | 168 | 82 | 86 | 12 | 776 | 25 | 48 | 82 | 273 | 98 | 273 | 98 |
| Milk | 11 | 1 | 14 | 8 | 235 | 235 | 225 | 40 | 12 | 1 | 250 | 2,000 | 24 | 3 | 180 | 82 | 28 | 1 | 780 | 14 | 17 | 17 | 289 | 29 | 289 | 29 |

All delivery wagons should be covered. They are of three principal types. That most used is one where the driver mounts over the wheel and is open at the ends; in some cities the wagon with a step between the wheels and a door in the middle is used. In still others the step and door is at the rear and the man drives standing up with the cases of bottles in front of him.

The cost of operating milk wagons varies greatly in different cities according to the price paid for horses, labor, feed, stabling, etc. Some data furnished by Thomson are given in Table 100.

The life of a horse and of a wagon depends on their quality and on the usage and care they receive and of course varies a great deal with these


FIG. 49.—Delivery wagon with the door in the rear.

different factors. So far as the writer has been able to find out by inquiry the usual estimate of the life of each is 3 or 4 years.

The delivery routes should not be allowed to grow up in haphazard fashion; on the contrary, they should be carefully planned. Generally the more deliveries per mile traveled, the less is the cost of delivery per quart, and delivery over well-paved streets is attended with the least wear and tear on the horse and wagon. Therefore, it should be the aim of the dealer to build up his business in well-populated and well-cared-for sections of the city. He should know the amount of milk carried and the distance traveled by each wagon. The routes of the several wagons should be laid out in such a way that they cross and recross each other as little as possible. Conditions in the residential sections should be studied; in some, the houses are flush with the sidewalk while in others, they may

set back a long way; of course it takes more time and therefore costs more to deliver to the latter. In apartment-house districts it should be noted whether deliveries are made on the ground floor for the whole house or whether deliveries are made on all the floors.

The Dairy Division of the U. S. Department of Agriculture has collected data with regard to the distribution of milk that are set forth in Tables 101 and 102 and a Committee of the International Milk Dealers' Association received reports from 21 of its members representing three Provinces and 13 States as to the number of hours their milk remained on the delivery wagons; the information is summarized in Table 103.

TABLE 101.—AVERAGE LOAD CARRIED BY MILK DELIVERY WAGONS IN FIVE CITIES OF THE UNITED STATES (U. S. DEPARTMENT OF AGRICULTURE)

| City | Total number of gallons included | Total number of wagons included | Average load in gallons |
|---|---|---|---|
| District of Columbia.. | 13,202 | 173 | 76.3 |
| Boston.............. | 22,599 | 305 | 74.0 |
| Pittsburgh.......... | 9,190 | 125 | 73.5 |
| Baltimore........... | 12,614 | 182 | 69.3 |
| Philadelphia........ | 39,512 | 571 | 69.2 |

TABLE 102.—MILES TRAVELED, LOAD CARRIED AND QUARTS DELIVERED BY THE WAGONS OF DEALERS IN FOUR CITIES OF THE UNITED STATES (U. S. DEPARTMENT OF AGRICULTURE)

| City | Number of wagons | Number of dealers | Ave. miles traveled | Number of miles varying from | Average load in quarts per wagon | Number of quarts varying from |
|---|---|---|---|---|---|---|
| Pittsburgh............ | 41 | 1 | 14.20 | 5.5–30.7 | 327.0 | 183–448 |
| District of Columbia.... | 63 | 14 | 18.60 | 10.4–30.0 | 301.8 | 140–648 |
| Baltimore............. | 11 | 1 | 20.20 | 9.9–30.5 | 215.0 | 112–316 |
| Boston............... | 22 | 1 | 20.35 | 7.7–43.6 | 245.0 | 180–290 |

It should be recognized that the cost of delivering milk in pint bottles is greater than for delivering in quarts, for pint bottles take longer to fill and clean and disappear from service faster than quarts. It takes as long for a driver to deliver a quart of milk as a pint and of course the return for his time is less. So the dealer is justified in charging a higher rate for milk delivered in pints than for that in quarts.

The delivery of milk in quart as compared with pint bottles was studied by the Dairy Division of the U. S. Department of Agriculture. The results thereof appear in Table 104.

Thus 41 per cent. of the bottled milk of 74 dealers was put out in pint bottles and they each handled 1.39 pint bottles to every quart bottle.

Pint and ⅓-qt. bottles are used in certain deliveries such as those at

TABLE 103.—NUMBER OF HOURS 21 DEALERS CARRY MILK ON DELIVERY WAGONS (INTERNATIONAL MILK DEALERS)

| Location of dealer | Mass. | N.Y. | Pa. | Pa. | Pa. | Pa. | Pa. | Md. | Ohio | Ind. | Mich. | Wis. | Minn. | Ia. | Ky. | Wash. | Cal. | P.Q. | P. Ont. | P. Ont. | P. Man. | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum........ | 6 | 9 | 14 | 8 | . | 10 | 8 | 8 | . | 8 | 10 | 6 | 10 | 6 | 4 | 12 | 10 | . | 6 | 7 | 6 | 8.2 |
| Minimum........ | 0 | 5 | 3 | 4 | . | 0 | ½ | 6 | . | 4 | 1 | ¼ | 1 | 2 | 2 | ½ | 2 | . | 2 | 1/12 | ¼ | 1.9 |
| Average........ | 3 | 1 | . | 6 | 6 | 3 | 4 | 7 | 4 | 6 | . | 5 | 8 | 3 | 3 | 6 | 6 | 4 | 4 | 3 | 3 | 4.6 |

hotels and restaurants where milk is served in the original container and are profitable partly because the loss of bottles is small; therefore, a dairyman is justified in taking on this class of trade.

Another matter to be considered is whether one or two deliveries shall be made a day. The reasons advanced for two deliveries are that the customer receives his milk fresher and so in hot weather in better condition, and from the dealer's point of view that his wagon is likely to pick up extra orders on the second trip, and his drivers have more time for canvassing and bill collecting. The advantage that may come to the customers from receiving fresher milk is to some extent offset by the fact that it may be less thoroughly cooled before being loaded onto the wagon and there is a disadvantage to the dealer in that the second delivery is made in a much warmer period of the day so that the milk requires more ice. Studies by the Dairy Division of four routes of two dealers in a city where two deliveries a day were customary showed that the second trip was 70 per cent. as long as the first and required 97 per cent. as much time but that less than 20 per cent. as much milk was delivered. The amount was so small that it might easily have been carried on the first load.

The first careful study of milk distribution made in the United States was that by Williams of Rochester, N. Y. Some of the conclusions he reached were: that such distribution of milk as is found in Rochester and most American cities is very wasteful and is responsible for much of the bad milk sold; that were this waste avoided by proper methods of distribution, cleaner and better milk could be furnished the consumer at 2 cts. a quart less than he now pays; that the attempt to improve the quality of public milk supplies without taking cognizance of the tremendous wastes in present methods of distribution undoubtedly accounts for the failure to advance in the solution of the municipal milk problem.

Table 105 shows how in every one of the sections studied an unnecessary number of distributors were pounding the roads to pieces with their wagons and how the territory might be covered by a single distribution.

TABLE 104.—THE DELIVERY OF MILK IN PINT AS COMPARED WITH QUART BOTTLES IN FIVE CITIES OF THE UNITED STATES (U. S. DEPARTMENT OF AGRICULTURE)

| City | Number of dealers | Number of quarts | Number of pints | Proportion of pints to quarts |
|---|---|---|---|---|
| Boston | 27 | 99,844 | 64,830 | 0.65 |
| Washington | 13 | 33,356 | 35,600 | 1.06 |
| Pittsburgh | 9 | 26,917 | 37,040 | 1.37 |
| Philadelphia | 15 | 80,922 | 173,300 | 2.14 |
| Baltimore | 10 | 18,713 | 50,738 | 2.71 |
| Total | 74 | 259,752 | 361,508 | 1.39 |

TABLE 105.—UNNECESSARY STREET TRAFFIC OF MILK DISTRIBUTORS IN ROCHESTER, N. Y. (WILLIAMS)

| Class | No. of homes in section | No. of homes supplied by distributors | No. of distributors supplying section | No. of miles distributors now travel in supplying section | No. of miles a single distributor would travel in section to render same service |
|---|---|---|---|---|---|
| Chiefly colored | 231 | 165 | 23 | 20 | 2.0 |
| American laboring | 523 | 432 | 55 | 45 | 3.0 |
| American laboring | 462 | 340 | 40 | 30 | 3.0 |
| American laboring | 191 | 167 | 31 | 21 | 1.7 |
| American laboring | 786 | 786 | 62 | 57 | 5.4 |
| German-American laboring | 527 | 508 | 39 | 61 | 4.4 |
| German laboring | 234 | 145 | 39 | 20 | 1.7 |
| Italian laboring | 643 | 253 | 61 | 36 | 2.0 |
| Jewish laboring | 477 | 363 | 57 | 30 | 1.7 |
| American middle | 450 | 443 | 26 | 48 | 2.4 |
| Well-to-do | 283 | 273 | 27 | 24 | 2.6 |
| Well-to-do | 120 | 120 | 14 | 12 | 1.2 |
| Well-to-do | 201 | 166 | 25 | 21 | 2.5 |
| Well-to-do | 99 | 91 | 17 | 14 | 2.0 |
| Well-to-do | 209 | 216 | 34 | 38 | 2.5 |

Williams divides the distributors in Rochester into four groups according to the volume of business done. The first group is composed of 25 dealers who sell not more than 150 qt. of milk daily; the second group consists of 101 distributors who sell from 151 to 300 qt.; the third is made up of 44 dealers who distribute from 131 to 1,000 qt.; in the fourth group are three companies who dispense from 3,000 to 8,000 qt. In Table 106 is shown the result of Williams' study of the business of these dealers.

As illustrative of Williams' analysis of Table 106 his remarks in regard to the 25 distributors selling not more than 25 qt. a day may be quoted. These distributors require the services of 29 men, 34 horses and 26 wagons. They travel 199 miles to supply 3,016 qt. of milk to

TABLE 106.—THE TOTAL ACCOUNTING OF MILK DISTRIBUTORS OF ROCHESTER, N. Y., GROUPED ACCORDING TO THE VOLUME OF BUSINESS DONE (WILLIAMS)

| Schedules | Distributors selling daily | | | | Total |
|---|---|---|---|---|---|
| | Not more than 150 qt. | From 151 to 300 qt. | From 301 to 1,000 qt. | 1,000 qt. or more | |
| Distributors, number...... | 25 | 101 | 44 | 3 | 173 |
| Milk, retail, quarts........ | 2,887 | 21,368 | 17,180 | 8,900 | 50,335 |
| Milk, wholesale, quarts ... | 129 | 2,411 | 3,415 | 6,000 | 11,947 |
| Total milk sold, quarts.. | 3,016 | 23,799 | 20,599 | 14,900 | 62,314 |
| Men employed, number.... | 29 | 133 | 99 | 95 | 356 |
| Horses employed, number.. | 34 | 160 | 101 | 65 | 360 |
| Wagons employed......... | 26 | 137 | 92 | 50 | 305 |
| Length of route, miles...... | 199 | 1,053 | 616 | 641 | 2,509 |
| Customers, number........ | 1,885 | 13,915 | 9,490 | 9,800 | 35,090 |
| Value milk-room equipment | $2,407 | $17,295 | $16,750 | $38,450 | $76,902 |
| Value horses and wagons... | 8,815 | 45,105 | 28,495 | 25,035 | 107,450 |
| Value real estate.......... | ........ | ........ | ........ | 96,700 | 96,700 |
| Total investment........ | $11,222 | $62,400 | $44,245 | $160,185 | $278,052 |
| Interest, depreciation on investment ............ | $6.17 | $34.17 | $25.16 | 45.15 | $110.65 |
| Cost of coal and ice....... | 8.92 | 42.25 | 39.03 | 17.20 | 107.40 |
| Milk shrinkage, waste, etc. | 4.35 | 36.59 | 28.55 | 14.55 | 84.04 |
| Maintenance horse and wagon................. | 25.30 | 152.50 | 101.00 | 100.00 | 378.80 |
| Daily wages, labor........ | 5.60 | 48.95 | 74.20 | 193.06 | 321.81 |
| Cost of bottles............ | 7.38 | 77.36 | 74.89 | 21.00 | 180.63 |
| Total cost distribution... | $57.72 | $392.82 | $342.83 | $390.98 | $1,184.35 |
| Amount paid producer..... | 128.71 | 999.55 | 880.44 | 886.40 | 2,895.10 |
| Total cost to distributor. | $186.43 | $1,392.37 | $1,223.27 | $1,277.38 | $4,079.45 |
| Milk receipts, retail....... | $213.31 | $1,535.05 | $1,254.67 | $682.00 | $3,685.03 |
| Milk receipts, wholesale.... | 1.00 | 138.26 | 195.87 | 314.50 | 548.63 |
| Cream receipts............ | 6.75 | 60.84 | 106.20 | 67.51 | 241.50 |
| Total receipts .......... | $220.06 | $1,734.15 | $1,556.74 | $1,366.01 | $4,876.96 |
| Labor profit............. | 37.59 | 341.78 | 333.47 | 78.58 | 791.42 |
| Labor loss............... | 3.96 | ......... | ......... | ......... | ......... |

2,270 homes. There is invested in 23 insanitary, poorly equipped milk rooms, $3,300; in inferior horses and wagons $8,815. The wage and labor profit received by these 29 men is approximately $33.63 daily, an aver-

age of $1.16 per day per man. If this service were concentrated in one section under a single efficient distributing agency, thus avoiding overlapping routes, waste of labor and reduplication of equipment, it could be rendered in a superior manner by a much smaller force and equipment as indicated in Table 107.

Table 107.—Cost of Distributing 3,016 Qt. of Milk by 25 Petty Distributors of Rochester, N. Y., Compared with Cost of Distributing the Same Under a Model System (Williams)

| Under present system | | Under model system | |
|---|---|---|---|
| 29 men at $1.16 per day | $33.63 | 3 men at $2.50 per day | $7.50 |
| 34 horses and 26 wagons, maintenance | 26.00 | 4 horses, daily maintenance | 5.00 |
| | | 1 truck, maintenance | 0.25 |
| | | 1 motor truck part of 1 day | 2.00 |
| Total | $59.63 | Superintendence | 6.00 |
| | | | $20.75 |

The $3,300 now invested in 23 small insanitary milk rooms would furnish a very good equipment for one sanitary milk depot. A complete outfit of horses and trucks could be had for $1,100, a saving of at least $7,700. The economies that could be effected by these and other unnecessary wastes on this amount of service would lessen the cost of distribution by about $40 per day, or 1.5 cts. per quart.

Table 108 is Williams' statement of the delivery of milk in Rochester at the present time and how it might be delivered under a model system.

Table 108.—The Delivery of Milk in Rochester, N. Y., as at Present, and as It Might be Delivered Under a Model System (Williams)

| Present system | Model system |
|---|---|
| 356 men and in many cases their families | 90 men |
| 380 horses | 50 horses |
| 305 wagons | 25 horse-drawn trucks |
| 2,509 miles of travel | 300 miles of travel |
| $76,600 invested in milk-room equipment | $75,000 equipment for sanitary plants |
| $108,000 invested in horses and wagons | $30,750 equipment of horses and trucks |
| $2,000 present daily cost of distribution | $600 estimated daily cost of distribution |
| $720,000 present yearly cost of distribution | $22,000 estimated yearly cost of distribution. |

The same conditions exist in other American cities; thus the Dairy Division of the U. S. Department of Agriculture in 1915 found that in the District of Columbia the shortest distance traveled by any one of 98 wagons studied was 10.4 miles and the longest was 30, the average being 19.1 miles. At the time there were 510 miles of street and 250 wagons in the district so that if each wagon covered 19.1 miles they traveled in all 4,775 miles or 93 times the total number of miles of street and about eight out of every nine wagons were used uneconomically. More than 80 dealers were making deliveries.

While the single central-delivery system looks very attractive, its practicability is not unchallenged. The objections raised to it by milk dealers of New England are set forth in the Boston Chamber of Commerce report of 1915. They are that there would be: (1) Loss in teams and trucks, for each company would have to maintain motor trucks or teams to carry its product to the central delivery plant which vehicles would be idle the greater part of the day. (2) There would be difficulty in stacking the load, for it would be impossible to load the delivery truck in such a way that the several brands of milk and the various-sized bottles of the different dealers could be handled with celerity. (3) Only by giving advance orders could the customer obtain extra milk since it would be impossible for the wagon to carry a surplus supply of all dealers. (4) The loss in bottles would be greatly increased as no one would take as keen an interest in the recovery of bottles as the present drivers or salesmen do. (5) The drivers solicit trade, collect bills and look after bottles, but under a central-station system each dealer would have to hire one or more men to attend to these things. (6) The cost of advertising would be increased because the advertising that each dealer now gets from his own delivery wagon would be eliminated.

There are three ways in which a central-delivery system might be operated, namely: (1) by the producers on a coöperative system; (2) by dealers as a joint stock company; and (3) as a municipally owned plant. There have been but few central-delivery systems operated in the United States so that conclusions cannot be drawn from practice but such attempts as have been made at operating them have not been long-lived. Producers as a rule lack in experience and have strong individualistic tendencies so that they are liable to losses from mismanagement and the tendency of members of the coöperative association to break away and strike out for themselves. At Topeka, Kan., for example, the Producers Creamery Co. went to the wall after a brief existence. In some small cities as DeKalb, Ill., Kalamazoo, Mich., and Lawrence, Kan., private companies for a time have been practically the sole distributors and have been able to render efficient service at low cost but such companies as a rule lack stability for some stockholder or outsider sees a chance for a bigger profit and starts competition. The nearest approach to privately operated single plants are those of the big metropolitan dealers of which there are usually but two or three, certainly but few, and rarely only one in a city. These large companies reduce but do not entirely eliminate the loss that arises from numerous delivery wagons traversing the same streets every morning.

A municipally owned milk plant looks particularly attractive to the small city where no one dealer has felt justified in expending the capital to erect and equip a modern plant for clarifying, pasteurizing, cooling and bottling milk. It is felt that the city might do this and that an ex-

pert might be hired to run the plant and to teach the dairy farmers better methods of production. Large cities, too, have considered the proposition. In 1915 the matter was brought to a head in Seattle, Wash., where a dealer applied for the sole privilege of distributing milk in the city. The council determined to investigate the advantages of a municipally owned plant. The city's milk inspector, A. N. Henderson, has already filed a preliminary report on the matter and is continuing his investigation. In the course of his studies he was unable to find a single municipally operated plant in the United States. Undoubtedly the reason that the experiment has not been tried is that the people positively decline to entrust the care of such a vital necessity as milk to American commercial politics.

The milk-consuming public would very much like to know what the profits in the city milk business are. Some people believe them to be large, others are of the opinion that they are moderate while dealers as a whole volunteer very little information on the subject. Some contractors state that taking the country as a whole, the profit ranges on the average from ¼ to ⅓ ct. per quart of bottled milk. The only specific statement of a larger dealer that the writer has seen in print is that of H. P. Hood and Sons of Boston, Mass., which is presented in Table 109.

TABLE 109.—COST OF DELIVERING 1 QT. OF MILK TO THE CONSUMERS (H. P. HOOD AND SONS)

| | Per quart |
|---|---|
| Country expenses: | |
| Transportation, labor, ice, cans and stoppers, can washers and miscellaneous items | $0.0102 |
| City expenses: | |
| Pasteurizing, washing and bottling, glass jars, etc | 0.0103 |
| Salaries of drivers, helpers, foremen and salesmen | 0.0127 |
| Teams expense, including horses, wagons and harness | 0.0070 |
| Miscellaneous expenses, including bookkeeping, stationery, advertising matter, carfares, telephone calls and bad debts | 0.0038 |
| Total city expenses | $0.0338 |
| Total expenses, city and country | 0.0440 |
| Shrinkage at 2 per cent. and loss in carrying surplus | 0.0037 |
| Grand total expenses | $0.0477 |
| Average price paid producer per quart in the middle zone from Oct. 1, 1911, to Oct. 1, 1912 | 0.0390 |
| Net cost per quart delivered to customer, family trade | $0.0867 |

As the average price paid per quart for bottled milk in Boston is 9 cts., the profit according to these figures is ⅓ ct. a quart.

At the time of the milk strike in New York in the autumn of 1916, Borden's Condensed Milk Company issued the statement on the cost of milk that appears in Table 110.

Table 110.—Statement of the Average Price Received, Classified Cost and Net Profit Realized per Quart of Milk Handled by Borden's Condensed Milk Company in Eastern Territory during the Year Ended June 30, 1916

| | | |
|---|---|---|
| Price Received | | $0.0803 |
| Cost: | | |
| Milk | 0.0369 | |
| Factory expense | 0.0126 | |
| Freight | 0.0072 | |
| Selling and delivery expense | 0.0201 | |
| General expense | 0.0009 | |
| Total cost | | $0.0777 |
| Net profit | | 0.0026 |
| Percentage of profit on net sales | 3.25 per cent. | |

Stated in another form the Company says that of the consumer's dollar 16.44 ct. goes for materials and supplies such as bottles, cans, feed, bedding, ice, etc., for the railroad 9.03 ct., for labor 25.41 ct., for the dairyman 45.87 ct. and to the stockholders of the company 3.25 ct.

The cost of producing and of delivering milk to the consumer must vary considerably in the different dairy sections and cities but such information as the writer has leads him to the opinion that there is not a great difference in the profit per quart of bottled milk which is made by the dealers of the eastern half of the United States.

With regard to the cost of operating a small milk route Kelly has recently made the following estimate. The equipment required and the cost thereof for handling 75 gal. a day in 250-qt. packages is shown in Table 111.

Table 111.—Investment Required to Operate a Milk Plant Handling 75 Gal. a Day (Kelly)

| | | | |
|---|---|---|---|
| Boiler | $150 | Motor | $75 |
| Bottle filler | 150 | Miscellaneous | 150 |
| Pasteurizing outfit | 275 | Cans | 40 |
| Bottle washer | 75 | Bottle cases | 30 |
| | | Total | $945 |

Charging 25 per cent. as the annual rate of interest and depreciation on the $945 invested in plant equipment and 15 per cent. on the $500 that would have to be invested in delivery equipment and dividing these charges by 12 the statement arrived at in Table 112 gives a fair idea of the probable monthly expenses.

If the milk was purchased at 4 cts. a quart $360 would have to be added to this monthly expense which would make a total of $529.68. If 9,000 qt. were sold at 7 cts. a quart it would yield a gross income of $630 per month which would leave approximately $100.32 for the labor and

TABLE 112.—MONTHLY EXPENSES OF OPERATING A 75-GAL. DELIVERY ROUTE (KELLY)

| | | | |
|---|---|---|---|
| Interest and depreciation on $945 | | | $19.69 |
| Interest and depreciation on $500, delivery equipment | | | 6.25 |
| Rent of building | $30.00 | Caps | 2.50 |
| Keeping of horses | 20.00 | Water | 1.50 |
| Helper | 40.00 | Bottles | 16.00 |
| Coal | 6.00 | Washing powder | 1.50 |
| Ice | 12.00 | Miscellaneous expenses | 5.00 |
| Electricity | 1.50 | Shrinkage and cans | 7.74 |
| | | Total | $169.68 |

TABLE 112.—VARIATION OF COST OF EACH OPERATION PER QUART
(Boston Chamber of Commerce, 1915)

| Operation | Cost | Varying figures of different companies | | | |
|---|---|---|---|---|---|
| Collection | Lowest | $0.00250 | $0.00010 | $0.00200 | |
| | Highest | 0.01500 | 0.01910 | 0.01100 | |
| | Usual (c) | 0.00625 | 0.00660 | 0.00300 | |
| Country plant | Lowest | ......... | 0.00250 | 0.00340 | |
| | Highest | ......... | 0.01125 | 0.00480 | |
| | Usual | 0.00750(a) | 0.00400 | 0.00400 | |
| Railroad transportation | Lowest | ......... | 0.00440 | 0.00390 | |
| | Highest | ......... | 0.01030 | 0.00910 | |
| | Usual | 0.00500 | | 0.00438 | |
| City plant | Lowest | ......... | 0.00400 | ......... | |
| | Highest | ......... | 0.00850 | ......... | |
| | Usual | 0.0050(b) | 0.00700 | 0.01350 | $0.0068 |
| Distribution, family trade | Lowest | ......... | 0.02250 | ......... | |
| | Highest | ......... | 0.05000 | ......... | |
| | Usual | ......... | 0.03000 | 0.03860 | 0.0235 |
| Distribution, retail stores | Lowest | ......... | 0.01000 | 0.01880 | |
| | Highest | ......... | 0.35000 | 0.02190 | |
| | Usual | 0.01000 | 0.015–0.02 | 0.02050 | 0.0095 |
| Distribution, wholesale trade | Lowest | ......... | 0.00400 | 0.01030 | |
| | Highest | ......... | 0.00529 | 0.01280 | |
| | Usual | 0.00500 | 0.00470 | 0.01130 | |

(a) Including pasteurization.

(b) Excluding pasteurization.

(c) Since there is a great difference between the highest and lowest costs the "usual" cost is often far from the cost of the greater part of the milk entering metropolitan Boston.

income of the owner. Losses would occur from bad bills, etc.; 100 gal. a month could be handled with practically the same equipment and figured on the same basis would yield a theoretical profit of $178 per month.

The Boston Chamber of Commerce report of 1915 takes up the cost of distributing milk and cream in New England. The report states that milk is delivered: (1) to family trade in bottles; (2) to retail stores, generally in cases of 12 quart bottles or 20 pint bottles; (3) to wholesale customers in cans. This class includes hotels, restaurants, boarding houses, institutions, delicatessen shops, drug stores, bakeries, ice cream manufacturers, etc. In Greater Boston the milk and cream is apportioned to these three classes of consumers as follows: to family trade in bottles, milk 20 to 25 per cent., cream 5 to 15 per cent.; to retail stores in bottles, milk 20 to 25 per cent., cream 10 to 20 per cent.; to wholesale consumers in cans, milk 50 to 60 per cent., cream 50 to 75 per cent. It is estimated that since there are fewer hotels, restaurants, boarding houses, etc., in cities of 100,000 inhabitants, a larger percentage of the milk goes into family trade and that in cities of 5,000 to 25,000 the family trade is 80 per cent. of the total.

The cost of each operation in the progress of the milk from the producer to the consumer, the report sets forth as in Table 112.

The report discusses the cost of the several items as follows:

**Collection.**—The cost of collection from the producer and delivery to the country plant or car varies from ¼ to 1½ cts. per quart, depending on the length of the route, the character of the roads, whether hilly or level, the regularity of amounts collected per day throughout the entire year, and the total amount per day the entire route will average. Local conditions govern this entirely.

**Country Plant.**—Expenses vary here from ¼ to 1¼ cts., depending almost entirely on the number of quarts put through the plant, and the number of operations necessary before loading on the car, and the great variation in the monthly receipts of milk and cream (since the overhead expenses remain practically the same throughout the 12 months, and in many sections there is an extreme variation in the monthly receipts; receive more in April, May, June and July than in the other 8 months).

**Transportation on Railroads.**—This varies from ¼ to 1¼ cts. in leased cars, according to the distance, the number of railroads the car uses, the number of days the cars fail to carry the minimum number of quarts which must be paid for per carload, the number of days the milk and cream has to be iced, and the number of stops necessary to complete a carload (this requiring the services of one or more caretakers).

Rates on milk and cream shipped by express and as "excess baggage" are not given in the table or compared, as this will be found under the head of "Railroad Transportation."

**City Plant.**—The cost varies from ½ to 1½ cts., depending on the overhead charges of the plant, the arrangement and machinery in operation, the regular amount of the milk put through and the cost of labor and ice.

## DISTRIBUTION

**Family Trade.**—The cost here varies from 2¼ to 5 cts. in bottles, depending on the loss in bad bills (average monthly bill of 30 qt., $2.70; many move or

avoid payment, bill too small to pay for costs of collection, but the aggregate is a substantial amount), non-return of bottles, the density of the population, the number of stops required to deliver a load (depending on whether the customer takes a pint, quart or 2 or 3 qt.), and the average number of quarts that are carried through the year (which varies from 200 to 400 qt. per team). On many routes people are away during the summer, leaving a team for months with only half of its regular load.

**Retail Stores** (Bottles in Cases).—The cost of delivery to the retail stores varies from 1 to 2½ cts., depending on the distance traveled, the number of stops necessary to deliver a load (10 to 35), and whether or not two trips can be made in a day.

**Wholesale Trade.**—The cost to the wholesale consumer varies from ¼ to 1 ct., depending on the number of stops, the distance, the number of trips a two-horse team or motor truck can make in a day, and the size of the container, whether 8-, 8½-, 20- or 40-qt. or 21½-qt. container (a 20-, 21½- or 40-qt. container costing ¼ ct. to ½ ct. per quart less to handle).

Early in 1915 the Federal Government in a coöperative investigation with the Massachusetts Agricultural College obtained the cost of distributing milk from 86 dealers in six cities and towns of Massachusetts, including Worcester and Springfield. The cost of retailing began with the delivery of the milk at the milk plant of the distributor, or in the case of producers with the preparation of the milk after it had been strained and put in cans. All labor costs including the distributor's own valuation of his time and of the time given him by various members of his family, the interest on the investment, depreciation, insurance, taxes, all overhead charges, cost of horse labor, including feed, depreciation on horses and equipment and all losses in bottles and wastes were taken into consideration. The cost of distributing milk figured on this basis means that milk could be delivered at this cost but that there would be no profit above wages. The average cost of delivery in the six cities was 2.64 cts. and the average cost for the 42 dealers in Worcester and Springfield was 2.79 cts. Increase in the cost of labor and other costs since the study was completed makes it necessary to add 25 per cent. or more to these figures.

Cance, who conducted the investigation, found that in Springfield one dealer distributed for 2.2 cts. and another for 4.71 cts. per quart. As a whole the distributing costs run about as follows:

Of the dealers investigated:

6 per cent. distributed milk for less than 1½ cts.
21 per cent. distributed milk for 1½–2 cts.
24 per cent. distributed milk for 2–2½ cts.
19 per cent. distributed milk for 2½–3 cts.
18 per cent. distributed milk for 3–3½ cts.
12 per cent. distributed milk for more than 3½ cts.

That is to say, 70 per cent. of the dealers handled milk for less than 3 cts. per quart.

These tremendous variations are due to a variety of causes.

1. It is only evident that the methods of distributing milk are not standardized. There is no agreement as to the size of plant and equipment necessary to handle 500 to 1,000 or 1,500 qt. of milk per day. Some dealers have a very efficient plant with small operating costs and sell good milk at a good profit. Others by their own inefficiency, ill-proportioned equipment and out-of-date methods are making little or nothing at the expense of the consumer.

The fact that 51 per cent. of the distributors could do business, and pay themselves wages, interest on the plant, depreciation and all losses and expenses for less than 2½ cts. per quart is evidence that milk can be retailed economically.

2. Delivery costs are in many cases very high. An analysis of costs into "Preparation for Delivery," "Delivery" and "Overhead Expenses" by groups, is as follows:

| | Preparation costs, cents | Delivery costs, cents | Overhead costs, cents |
|---|---|---|---|
| Group I, 20 firms | 0.46 | 0.89 | 0.29 |
| Group II, 10 firms | 0.45 | 1.05 | 0.32 |
| Group III, 27 firms | 0.65 | 1.14 | 0.25 |
| Group IV, 20 firms | 0.90 | 1.6 | 0.43 |

In all cases delivery is a large item, more than 50 per cent. of the total. In group II it amounts to nearly 58 per cent.

3. Long hauls and small loads per wagon are two causes for high delivery costs. In some instances the long hauls are necessary but often duplication of routes and long distances between customers are responsible for miles of useless travel and waste of both men and horse labor.

The small load is sometimes the result of the long haul since the long haul decreases the number of deliveries a driver can make in a given time. It is obvious that one man can deliver more milk if he delivers 1 qt. at every house than if he delivers a quart at every fifth or every tenth house.

On the other hand, loads are often smaller than necessary, even under the circumstances, sometimes because of poor horse and wagon equipment, sometimes because of the inefficiency of the driver, sometimes for no apparent reason.

4. Many losses occur because of the competition of many small dealers. Surplus milk is a very grave problem, especially for a small

milkman. A large dealer can utilize his surplus at a comparatively small loss.

Losses due to spoiled milk and bad debts are heavy items in many cases and to the small dealer collections are unduly expensive. In Springfield the loss due to surplus, spoiled milk, and bad accounts as reported by ten dealers amounted to $3,379 annually or 96 cts. per thousand quarts delivered.

Under a competitive system there is a tendency to take on undesirable customers, to make expensive deliveries and to carry customers who buy milk in small quantities from three or four different milkmen.

Looked at from almost any angle, a large well-equipped plant, with outlying stations from which deliveries can be made over well-planned routes is more efficient and profitable to distributors than the present unorganized system of small independent competitive units. In the city of Erie, Pennsylvania, the producers formed a milk supply company about seventeen years ago and have been retailing their own milk to the greater part of the population ever since. The venture is a pronounced success and the business of the company has grown rapidly and steadily.

(*a*) They have given Erie an excellent quality of milk.

(*b*) At a lower price to the consumer than any neighboring cities of the same size.

(*c*) They have increased the load per driver, shortened the routes amazingly and lessened delivery costs.

(*d*) By means of a bonus system they have increased the wages of the drivers, and at the same time the number of customers served by each driver.

(*e*) In the meantime, the company has prospered financially (stock is three times its par value).

(*f*) The farmers have been getting more out of their milk than ever before.

One of the problems of city delivery is that of handling the "come backs" as the undelivered bottles of milk are called. After milk has been hauled about the city in midsummer it has usually acquired a high temperature and bacterial changes have started in it. Consequently it should not make another trip on the delivery wagon; nevertheless some dealers repasteurize it and send it out again. The more particular dealers utilize such milk by making it into butter and cheese. The milk code should prohibit the former practice and every inspector should make it a point to know how this part of the milk business is handled.

**Bookkeeping.**—Since every dealer is engaged in the purchase and sale of milk a system of bookkeeping is necessary. The larger firms have their accounts to keep with the individual dairymen from whom they buy milk, with the railroads which transport it and with the customers to whom they sell at wholesale and retail. Besides, an account should be

kept of the expenses of running the country branch and main plants. There should also be a system of cost accounting so that the expense of carrying on the different parts of the business may be known. This sort

MONTH OF ____________ 191__

**MR.** ______________________________

IN ACCOUNT WITH **ASHUELOT DAIRY CO.**
**MONADNOCK, N.H.**

| DATE | MILK LEFT | | CREAM LEFT | | BOTTLES RET'D | TICKET MEM | TICKETS SOLD | | CASH |
|---|---|---|---|---|---|---|---|---|---|
| | QTS | PTS | PTS | ½PTS | | | CASH | CREDIT | REC'D ON ACCT. |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 30 | | | | | | | | | |
| 31 | | | | | | | | | |
| TOTAL | | | | | | | | | |

Fig. 50.—Tally card.

of thing is new and very few concerns practice it. The larger firms appreciate the importance of keeping accounts but many of the small men

**CASH SHEET ASHUELOT DAIRY CO.**
**MONADNOCK N.H.**
ROUTE ______________ DATE ______________

| | PAGE | (FORM P) | AMOUNT | | |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Fig. 51.—Cash sheet.

who are both producing and selling their own milk do not and the consequence is that their losses from bad accounts and slack methods of purchasing are severe. Even when close attention is paid to collections

some loss is incurred through customers moving away and leaving small unpaid accounts that are not worth the expense of collecting, etc.

**ASHUELOT DAIRY CO. MONADNOCK, N.H.**

**REQUISITION ON COLD STORAGE FOR MILK AND CREAM**

**AND**

**MILK AND CREAM DELIVERY REPORT**

Date, ______________ 191____ Route No. 1

| | | Milk | | | | Cream | | | | | Double Cream | | | Butter Milk | | Towel | Blankets | Feed Bag | Cans |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OUT | Gals. | Qts. | Pts. | ½ Pts. | Gals. | Qts. | Pts. | ½ Pts. | Gills | Pts. | ½ Pts. | Gills | Qts. | Pts. | | | | |
| | 1st | | | | | | | | | | | | | | | | | | |
| | 2nd | | | | | | | | | | | | | | | | | | |
| RETURNED | Milk Cream D.C. & B. M. | | | | | | | | | | | | | | | | | | |
| | Bottles 1st | | | | | | | | | | | | | | | | | | |
| | Bottles 2nd | | | | | | | | | | | | | | | | | | |

| MILK | Gals. | Pts. | CREAM | Gals. | Pts. | Dbl. CREAM | Gals. | Pts. | BUTTERMILK | Gals. | Pts. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Received, | | | Received, | | | Received, | | | Received, | | |
| Returned, | | | Returned, | | | Returned, | | | Returned, | | |
| Lost or Gained | | | Lost or Gained | | | Lost or Gained | | | Lost or Gained | | |
| Sold, | | | Sold, | | | Sold, | | | Sold, | | |

Cash received from Customers, $ ______________; Tickets, ________ Checked by ____________

______________________________ Received for ASHUELOT DAIRY CO.

______________ Driver, ______________ Cashier

FIG. 52.—Driver's requisition on cold storage room.

**SPECIAL ORDER SLIP**

**ASHUELOT DAIRY CO.**

**MONADNOCK, N.H.**

Deliver to ______________________

M ______________________

St ________ No ________

| Order Received | To be Delivered | Order | |
|---|---|---|---|
| 5.30 P.M. 1 Feb. | 3 Feb. | | Milk |
| | | 1 Qt. | Grade A |
| | | | Grade B |
| | | | Cream |
| | | | Single |
| | | ½ Pint | Double |
| | | 1 Qt. | Buttermilk |

FIG. 53.—Special order slip.

There are two common ways of keeping account of the retail business, namely, by means of tickets and by the driver's tally sheet or route

book. Tickets are generally sold at so many for a dollar or some other sum and they usually call for a certain amount of milk or cream. The purchaser drops tickets for the amount of milk needed in an empty milk

**ASHUELOT DAIRY CO.– MONADNOCK, N.H.**
**DUMP ROOM REPORT**

Date ..............................

| IN | OUT |
|---|---|
| Milk from Cars .............. | To Milk Room .............. |
| " " Routes .............. | " Separator Room .............. |
| " " Milk Room (overflow) .............. | Ret'd to Farmers .............. |
| " " Pedlers .............. | |
| " " Modified Milk .............. | |
| Skim on Hand .............. | Skim to Milk Room .............. |
| " from .............. | Curd Room .............. |
| | Cars .............. |
| | Left Over .............. |
| | Signed .............. |

FIG. 54.—Dump room report.

bottle and leaves it on the doorstep for the driver who fills the order when he comes along. The system has the advantage of reducing business to practically a cash basis as long as competition does not introduce the

**ASHUELOT DAIRY CO. - MONADNOCK, N.H.**
**DAIRY REPORT**

Date ______________

| Patron | Not Full | Sour | Bitter | Frozen |
|---|---|---|---|---|
| Ole Grimes | 1 | | | |
| Dad Pevear | | 1 | | |
| Caesar Rice | | | | |
| | | | | |

Signed ______________

FIG. 55.—Dairy report.

custom of trusting people for tickets. Since people run out of tickets the driver has to carry a cash sheet to record occasional and extra sales. The great disadvantage of the ticket system is its uncleanliness and some

| ASHUELOT DAIRY CO. - MONADNOCK, N.H. PLATFORM REPORT | | | | |
|---|---|---|---|---|
| SOUHEGAN CARS | | | | |
| Car No. | Cans Milk on Car | Cans Milk to Milk Room | Cans Skim on Car | Cans Cream on Car |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| KEENE CARS | | | | |
| Car No. | Cans Milk on Car | Cans Milk to Milk Room | Cans Skim on Car | Cans Cream on Car |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| HANOVER CARS | | | | |
| Car No. | Cans Milk on Car | Cans Milk to Milk Room | Cans Skim on Car | Cans Cream on Car |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| WASHINGTON CARS | | | | |
| Car No. | Cans Milk on Car | Cans Milk to Milk Room | Cans Skim on Car | Cans Cream on Car |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| GREENFIELD CARS | | | | |
| Car No. | Cans Milk on Car | Cans Milk to Milk Room | Cans Skim on Car | Cans Cream on Car |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

FIG. 56.—Platform report.

**In Account with ASHUELOT DAIRY CO.**
**MONADNOCK**
**NEW HAMPSHIRE**

Creamery deliveries ______ lbs. = ______ gals. @ ___ ¢ ______
Bacteria average ______ @ ___ ¢ ______
For Tuberculin testing of Herd ______ @ ___ ½ ¢ ______
Total $ ______
Less for Skim Milk $ ______
" " ______ $ ______
Average test ______ @ ______ ¢ unit $
Check herewith to balance,

Payment for month ending

FIG. 57.—Statement to producers.

**ASHUELOT DAIRY CO. MONADNOCK, N.H.**

**In account with**

------------------------------------------

------------------------------------------

------------------------------------------

For **MILK** Month ending ------------------------------

Account rendered ______ ---------- Gals.

Corrected for ______ ---------- "
" @ ¢. $ ----------

Less for Cans Washed ______ @ 1¢ $ ----------
" " Tags @ 10¢ per 100 ______ ----------
" " Freight on Returns ______ ----------
" " Cans Repaired ______ ----------
" " ------------------------------
" " ------------------------------

Check herewith to balance, $ ----------

| Corrections | | Corrections | | Corrections | | Corrections | |
|---|---|---|---|---|---|---|---|
| 1 | | 9 | | 17 | | 25 | |
| 2 | | 10 | | 18 | | 26 | |
| 7 | | 15 | | 23 | | 30 | |
| 8 | | 16 | | 24 | | 31 | |

FIG. 58.—Statement to producers.

slight danger it has of spreading contagion. Tickets should be printed on cheap paper and be used but once. Unfortunately they are often printed on heavy paper board and used again and again, till they become nasty and conceivably they may also become infected from being held in people's mouths and from being fingered by diseased persons and bacillus carriers. These considerations have led some cities to forbid the use of tickets.

**All Weekly Bills run from Sunday to Saturday Inclusive**

*Bill No.* ______________

*Week No.* __________ *Monadnock, N.H.* __________

*Mr.* ______________

*PLEASE RETURN ALL BOTTLES PROMPTLY*

**ASHUELOT DAIRY CO.**

**MONADNOCK, N.H.**

| | $ | Cts. |
|---|---|---|
| Delivered in month of ______ | | |
| " from Sunday ____ to Sat. ____ | | |
| BILL RENDERED ______ | | |
| ____ Pts., Qts., Gal., Jersey Milk ______ | | |
| ____ Pts., Qts., Gal., Cream ______ | | |
| ____ Lbs. Butter ______ | | |
| ____ Bottles Sterilized or Pasteurized Milk ____ | | |
| ____ Buttermilk ______ Curd ______ | | |
| ____ Qts., Ice Cream ______ | | |
| | | |
| | | |
| | | |
| *Total* ______ | | |

*TO PREVENT MISTAKES PLEASE KEEP ALL BILLS*

*Received Payment,*

______________

______________

FIG. 59.—Statement to customers.

The tally-card and cash-sheet system (Figs. 50 and 51) is kept in the form of a loose-leaved book that the driver carries with him and that is used to record the deliveries of milk, cream, etc., the bottles returned and the cash receipts. Daily on his return from the trip the driver casts up the tally sheet and makes returns to the main office which renders weekly or monthly statements to the customers either by mail or more usually by the driver who also makes collections. In the case of wholesale customers a tally sheet is usually posted at the place of business

and the amounts are entered thereon as deliveries are made, statements being rendered monthly.

The delivery wagon is loaded according to a requisition made on the cold storage room on some such form as Fig. 52, by the driver who is responsible for what is sent out and who makes an accounting for it all on his return.

In the general office a record is kept on forms such as Fig. 53, of special orders received by telephone and these are turned over to the proper driver for delivery.

In the large milk plants dump-room reports (Fig. 54), dairy reports (Fig. 56), and platform reports (Fig. 56) are kept. To the producers, statements such as forms Fig. 57 and Fig. 58, are rendered, and those to customers on forms similar to Fig. 59.

In addition to all this, there is the bookkeeping for the manufacturing departments, for the purchasing departments and for the accounts with the several employees so that the expense of maintaining the division of accounts is a considerable item in the ultimate cost of getting milk to the consumer.

**Retail Price of Milk.**—The final question is, at what price can milk be delivered? The price varies but not to so great an extent as might be expected. Table 113, compiled in the first 6 months of 1916, gives the average retail price per quart of milk in 105 cities in different parts

TABLE 113.—AVERAGE RETAIL PRICE OF MILK IN CENTS PER QUART IN 105 CITIES OF THE UNITED STATES

| New England States | | Middle Atlantic States | | South Atlantic States | |
|---|---|---|---|---|---|
| City | Price | City | Price | City | Price |
| Bangor, Me. | 8 | Albany, N. Y. | 8 | Ashville, N. C. | 10 |
| Boston, Mass. | 9 | Altoona, Pa. | 9 | Atlanta, Ga. | 10 |
| Burlington, Vt. | 8 | Binghamton, N. Y. | 9 | Baltimore, Md. | 9 |
| Fall River, Mass. | 9 | Buffalo, N. Y. | 8 | Charleston, S. C. | 11.5 |
| Manchester, N. H. | 8 | Erie, Pa. | 7 | Columbia, S. C. | 12.5 |
| New Haven, Conn. | 9 | Montclair, N. J. | 10 | Fredericksburg, Va. | 8 |
| Portland, Me. | 9.5 | Newark, N. J. | 9 | Jacksonville, Fla. | 12.5 |
| Providence, R. I. | 9 | New York, N. Y. | 9 | Macon, Ga. | 10 |
| Springfield, Mass. | 9 | Philadelphia, Pa. | 8 | Pensacola, Fla. | 12.5 |
| | | Pittsburgh, Pa. | 10 | Richmond, Va. | 10 |
| | | Scranton, Pa. | 9 | Roanoake, Va. | 10 |
| | | Syracuse, N. Y. | 8 | Savannah, Ga. | 12 |
| | | Trenton, N. J. | 8 | Washington, D. C. | 9 |
| | | Watertown, N. Y. | 7 | Wheeling, W. Va. | 5 |
| | | | | Wilmington, Del. | 8 |
| | | | | Wilmington, N. C. | 10 |
| Average | 8.72 | Average | 8.50 | Average | 10.00 |

| East North Central States | | West North Central States | | East South Central States | |
|---|---|---|---|---|---|
| City | Price | City | Price | City | Price |
| Chicago, Ill. | 8 | Aberdeen, S. D. | 7 | Birmingham, Ala. | 10 |
| Cincinnati, O. | 8 | Davenport, Ia. | 8.5 | Chattanooga, Tenn. | 10 |
| Cleveland, O. | 8 | Des Moines, Ia. | 8 | Corinth, Miss. | 10 |
| Detroit, Mich. | 8 | Dubuque, Ia. | 8.5 | Lexington, Ky. | 10 |
| Eau Claire, Wis. | 7 | Duluth, Minn. | 10 | Louisville, Ky. | 10 |
| Indianapolis, Ind. | 8 | Fargo, N. D. | 8 | Macon, Miss. | 10 |
| Joliet, Ill. | 8 | Kansas City, Mo. | 9 | Memphis, Tenn. | 10 |
| Madison, Wis. | 7 | Lawrence, Ks. | 7 | Mobile, Ala. | 10 |
| Milwaukee, Wis. | 7 | Manhattan, Ks. | 8 | Nashville, Tenn. | 10 |
| Springfield, Ill. | 10 | Omaha, Neb. | 8 | Sheffield, Ala. | 10 |
| Springfield, O. | 7 | St. Louis, Mo. | 8 | | |
| | | St. Paul, Minn. | 7.5 | | |
| | | Wichita, Ks. | 8.33 | | |
| | | Topeka, Ks. | 9 | | |
| Average | 7.77 | Average | 8.20 | Average | 10.00 |

| West South Central States | | Mountain States | | Pacific States | |
|---|---|---|---|---|---|
| City | Price | City | Price | City | Price |
| Dallas, Tex. | 10 | Albuquerque, N. M. | 10 | Corvalis, Ore. | 9 |
| Fayetteville, Ark. | 8.5 | Boise, Id. | 8.33 | Fresno, Cal. | 8.33 |
| Galveston, Tex. | 10 | Butte, Mont. | 10 | Los Angeles, Cal. | 9 |
| Little Rock, Ark. | 10 | Cheyenne, Wyo. | 9 | Portland, Ore. | 9.5 |
| Muscogee, Okl. | 9 | Colorado Springs, Col. | 7.5 | Salem, Ore. | 8.33 |
| New Orleans, La. | 10 | Denver, Col. | 8.33 | Sacramento, Cal. | 8.33 |
| San Antonio, Tex. | 10 | Helena, Mont. | 10 | San Diego, Cal. | 10 |
| | | Phenix, Ariz. | 8.33 | San Francisco, Cal. | 10 |
| | | Reno, Nev. | 8.33 | Seattle, Wash. | 9 |
| | | Roswell, N. M. | 10 | Spokane, Wash. | 12.5 |
| | | Salt Lake City, Utah | 8.33 | Takoma, Wash. | 9 |
| | | | | Walla Walla, Wash. | 8 |
| | | | | Yakima, Wash. | 8.5 |
| Average | 9.64 | Average | 8.92 | Average | 9.17 |

of the United States. The average price paid in these cities was 8.98 cts.; the minimum average price paid in any one city was 5 cts. and the maximum 12.5 cts.

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# CHAPTER VII

## CONTROL OF THE PUBLIC MILK SUPPLY

**Early Attempts at Control in Europe.**—Laws were enacted in Europe as early as the middle of the 14th century to prevent the sale of meat of diseased animals but laws to prevent the sale of impure milk came much later. The first English law to deal w th the quality of milk was passed in 1860 and merely prohibited the dilution of milk with water and the use of other substances to conceal such dilution. The first rules to regulate a city milk supply in Scotland were those enforced by the Willowbank Dairy of Glasgow in 1809 and the first in England were those of the Aylesbury Dairy Co. which in 1866 adopted the rules of the Scottish dairy. The Aylesbury Dairy Co. established two grades of milk; one included the milk that was believed to be fit for direct consumption and the other that which could not be so used and was, therefore, churned to butter. Prior to the establishment of the Aylesbury and other large dairies milk was sold by many men each of whom had but few cows, and standards of his own, consequently the quality of the milk was very variable. The concentration of the business into the hands of large companies, often of a coöperative character, gradually brought about more uniform conditions and something like standard milk quality.

It does not appear that city milk supply in the United States has been directly influenced by the methods of control developed in Europe but the excellent principles of general dairying and dairy manufacturing evolved by the Danes and Dutch are appreciated and the success of the Copenhagen Milk Supply Co. and the Trifolium Dairy have led American dairy students, visiting Denmark, to study their methods carefully.

**Early Attempts at Control in the United States.**—In the United States apparently the first law controlling the milk supply was that passed by the State of Massachusetts in 1856 prohibiting the adulteration of milk. The office of Boston Milk Inspector was established in 1859 and in the same year the use of distillery slop as a cattle feed was prohibited. In 1864 this law was revised, and the use of milk from diseased cows forbidden. This early Massachusetts legislation is interesting as showing that from an early period there has been a congested population in Boston which it has been difficult to supply with milk.

The dates at which the more progressive cities of the different sections of the United States undertook the control of their milk supply is shown in Table 114. In Table 115 the facts recorded in Table 114 are summar-

TABLE 114.—DATES AT WHICH 77 CITIES OF THE UNITED STATES BEGAN THE SAMPLING OF MILK AND THE INSPECTION OF DAIRIES

| New England States | Collection of milk | Dairy inspection | Middle Atlantic States | Collection of milk | Dairy inspection | South Atlantic States | Collection of milk | Dairy inspection |
|---|---|---|---|---|---|---|---|---|
| Boston, Mass. | 1859 | 1905 | Syracuse, N. Y. | 1877 | 1907 | Washington, D. C. | 1871 | 1895 |
| Providence, R. I. | 1870 | 1906 | Newark, N. J. | 1885 | 1882 | Baltimore, Md. | 1896 | 1896 |
| Hartford, Conn. | 1896 | 1908 | Buffalo, N. Y. | 1885 | .... | Atlanta, Ga. | 1903 | 1903 |
| Concord, N. H. | 1901 | 1908 | Pittsburg, Pa. | 1888 | .... | Richmond, Va. | 1904 | 1907 |
| Manchester, N. H. | 1901 | 1908 | Philadelphia, Pa. | 1890 | .... | Charlotte, N. C. | 1906 | 1906 |
| Portland, Me. | 1902 | 1908 | Rochester, N. Y. | 1891 | 1898 | Columbia, S. C. | 1907 | 1907 |
| Burlington, Vt. | 1907 | 1907 | Montclair, N. J. | 1894 | 1896 | Wheeling, W. Va. | 1907 | 1907 |
| New Haven, Conn. | .... | 1907 | New York, N. Y. | 1895 | 1902 | Wilmington, N. C. | 1914 | 1909 |
| Keene, N. H. | 1910 | 1910 | Scranton, Pa. | 1900 | 1907 | Savannah, Ga. | 1910 | 1901 |
| | | | | | | Jacksonville, Fla. | 1910 | .... |
| | | | | | | Spartanburg, S. C. | 1910 | 1910 |
| | | | | | | Fayetteville, N. C. | 1910 | 1912 |
| | | | | | | Greensboro, N. C. | 1910 | 1909 |
| | | | | | | Newark, Del. | 1911 | .... |
| | | | | | | Huntington, W. Va. | 1912 | .... |
| **East North Central States** | | | **West North Central States** | | | **East South Central States** | | |
| Detroit, Mich. | 1889 | 1908 | Topeka, Kan. | 1886 | 1886 | Nashville, Tenn. | 1888 | 1900 |
| Chicago, Ill. | 1893 | 1904 | St. Louis, Mo. | 1887 | .... | Louisville, Ky. | 1892 | .... |
| Indianapolis, Ind. | 1897 | 1897 | Minneapolis, Min. | 1895 | .... | Birmingham, Ala. | 1900 | 1900 |
| Cincinnati, O. | 1900 | .... | Kansas City, Mo. | 1902 | 1909 | Jackson, Miss. | 1911 | .... |
| Cleveland, O. | 1906 | 1906 | Sioux Falls, S. D. | 1904 | .... | Mobile, Ala. | 1905 | 1905 |
| Milwaukee, Wis. | 1906 | 1906 | Duluth, Minn. | 1905 | 1909 | | | |
| | | | Omaha, Neb. | 1906 | 1909 | | | |
| | | | Fargo, N. D. | 1906 | 1906 | | | |
| | | | Grand Forks, N. D. | 1906 | 1906 | | | |
| | | | St. Paul, Minn. | 1907 | 1907 | | | |
| | | | Wichita, Ks. | 1907 | 1907 | | | |
| | | | Bismark, N. D. | 1910 | 1910 | | | |
| | | | Minot, N. D. | 1910 | 1910 | | | |
| | | | Williston, N. D. | 1912 | .... | | | |
| **West South Central States** | | | **Mountain States** | | | **Pacific States** | | |
| New Orleans, La. | 1892 | 1906 | Denver, Col. | 1889 | 1892 | Los Angeles, Cal. | 1894 | 1895 |
| Galveston, Tex. | 1906 | 1907 | Salt Lake City, Utah | 1901 | 1909 | San Francisco, Cal. | 1895 | 1895 |
| San Antonio, Tex. | 1906 | 1907 | Colorado Springs, Col. | 1901 | 1901 | Seattle, Wash. | 1900 | 1908 |
| Oklahoma City, Okl. | 1907 | 1907 | Cheyenne, Wyo. | 1905 | 1905 | Portland, Ore. | 1910 | 1909 |
| Fort Worth, Tex. | 1908 | 1908 | Reno, Nev. | 1911 | 1911 | | | |
| Little Rock, Ark. | 1911 | 1911 | Butte, Mont. | 1912 | .... | | | |
| Guthrie, Okl. | 1911 | 1911 | Phoenix, Ariz. | 1913 | .... | | | |
| | | | Albuquerque, N. Mex. | 1913 | 1913 | | | |

TABLE 115.—PERIODS WITHIN WHICH THE REGULAR COLLECTION OF MILK SAMPLES AND THE INSPECTION OF DAIRIES WAS BEGUN IN THE SEVERAL SECTIONS OF THE UNITED STATES BY THE 77 CITIES APPEARING IN TABLE 114

| Period | New England States | | Middle Atlantic States | | South Atlantic States | | East North Central States | | West North Central States | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Collection of milk | Inspection of dairies | Collection of milk | Inspection of dairies | Collection of milk | Inspection of dairies | Collection of milk | Inspection of dairies | Collection of milk | Inspection of dairies |
| Prior to 1885 | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 1885–89 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 2 | 1 |
| 1890–94 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 1895–99 | 1 | 0 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 0 |
| 1900–04 | 3 | 0 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 0 |
| 1905–09 | 1 | 8 | 0 | 2 | 3 | 7 | 2 | 3 | 6 | 7 |
| 1910–14 | 1 | 1 | 0 | 0 | 8 | 2 | 0 | 0 | 3 | 2 |
| Total | 8 | 9 | 9 | 6 | 15 | 12 | 6 | 5 | 14 | 10 |

| Period | East South Central States | | West South Central States | | Mountain States | | Pacific States | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Collection of milk | Inspection of dairies | Collection of milk | Inspection of dairies | Collection of milk | Inspection of dairies | Collection of milk | Inspection of dairies | Collection of milk | Inspection of dairies |
| Prior to 1885 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 |
| 1885–89 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 1 |
| 1890–94 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 7 | 1 |
| 1895–99 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 7 |
| 1900–04 | 1 | 2 | 0 | 0 | 2 | 1 | 1 | 0 | 13 | 6 |
| 1905–09 | 1 | 1 | 4 | 4 | 1 | 2 | 0 | 2 | 18 | 36 |
| 1910–14 | 1 | 0 | 2 | 2 | 4 | 2 | 1 | 0 | 20 | 9 |
| Total | 4 | 3 | 7 | 6 | 8 | 6 | 4 | 4 | 76 | 61 |

ized. It appears that in the 20 years from 1885 to 1904 it was but slowly that American cities assumed control of their milk supplies. The early efforts of inspectors were directed toward the suppression of skimming and watering which had become very common; no city maintained regular dairy inspection until 1895; from then on the cities gradually took it up but it took 10 years to impress the country with its importance. In the five years from 1905 to 1909 no less than 33 of the cities under consideration accepted it and by 1913, 69 per cent. of them had done so. It cannot be said that the movement for municipal milk control proceeded in a regular manner from the older sections of the country to those that were settled later. On the contrary it was adopted wherever a city grew to sufficient size to make the supplying of it with milk a difficult problem. In the early years samples were examined only for fats and solids; bacterial examinations came later. Montclair, N. J., was the first city to make regular bacteriological examination of milk; most other cities have taken up this line of work since 1900.

In regard to these tables it should be stated that the Board of Health of New York City in 1873 forbade the sale of swill-milk, watered or adulterated milk and in that same year collected $2,400 in fines from 37 dealers who violated it. In 1876 the Board adopted an ordinance prohibiting the sale of watered, adulterated milk or skimmed milk. In enforcing this law the lactometer was used to determine the quality of the milk till 1895 when producers and dealers became so proficient in beating the instrument that the board was compelled to set a chemical standard and begin the regular collection and analysis of milk samples.

In Iowa since 1892, the local milk inspection in cities having a population of 10,000 or over, are appointed by the State Dairy Commissioner and the courts hold the legislature has never delegated the right to regulate the milk supplies to the cities, the power to control being vested only in the State Dairy Commissioner. In several of the Mountain States the control of milk supply is a function of the State. In Idaho none of the cities undertake to protect their milk supplies; that, since May, 1911, has been done by the State Department of Food, Drug and Hotel Inspection. In Montana, since 1912, the State has had charge of all milk supplies except that of Butte. In Nevada the State Department of Food and Drugs Control since Jan. 1, 1910, has been in charge of dairy inspection and milk analysis. Reno operates under a special ordinance in coöperation with the State Board of Health.

Milk control in the United States has received several impulses that have visibly affected its course. Among the most important of them were the invention of the Babcock test in 1891 which gave an easy and accurate way to determine butterfat in milk, the publication by Sedgwick and Batchleder in 1892 of the results of their bacteriological examination of Boston milk, which brought the public to a realization of the importance

of dairy sanitation, and the marketing of certified milk by Dr. Coit and Stephen Francisco in Montclair, N. J., in 1893, which marked the demonstration that it was commercially possible to produce clean wholesome milk. Other factors that have influenced milk control are bovine tuberculosis and other communicable diseases of men and animals that are transmissible in milk, the belief that impure milk was an important cause of infant mortality, and pasteurization.

The first milk inspection was started because consumers believed that they were not getting good milk and medical men were given charge of inspection because it was thought that watering and skimming milk made it injurious to health. It was because the public regarded the milkman who would jeopardize the health of infants and invalids by such practices as a despicable fellow that all who sold milk that did not conform to the standards were treated as criminals and the administration of the milk code in many instances became tainted with viciousness. Nowadays skimming and watering milk are regarded rather as robbery than as an attack on the consumer's health for while there is some danger that impure water may be used in adulterating and that filthy practices may attend the skimming, on the whole there is no reason for being very apprehensive and it is quite unlikely that the milk will be tampered with to such an extent that it will in any marked degree lose its nutritious properties. The real offense is in defrauding the customer, in making him pay whole-milk prices for skimmed and watered milk. The recognition of this fact and that it is principally infected milk that endangers the consumer has materially modified the conception of the way the milk code should be administered. The persistent milk adulterator should be vigorously prosecuted because he is making a living by robbing the public on the one hand and by carrying on unfair, cutthroat competition with his business rivals on the other, but the dairyman whose milk is watered by his inferior cows or is polluted through his ignorance is a fitter subject for the dairy instructor than the police court judge. It is the educative side of milk control that is most important.

**Principles of Modern Milk Control.**—The modern concept of milk control has been cogently stated by Woodward and briefly is this. Those interested in the milk business are the consumer, the producer, the vendor, the inspector and the judge. The city milk trade rises out of the consumer's demand for milk and it is his purse that supports the whole business; therefore his interests are paramount. Broadly speaking the interests of the consumer are those of all, consequently it is possible to handle the milk business as a community business. Were this not done, every man would have to make his own contract for milk specifying its quality, the conditions under which it should be produced, the way in which it should be delivered and having clauses permitting an agent of the owner to see that the contract is carried out and attaching penalties

for infractions of the agreement. The confusion resulting from such a system would be intolerable; so the community acting through the law-making power makes a contract or law which establishes the quality of the milk, the way it shall be handled, etc. It places the responsibility for seeing the law is lived up to in the hands of an inspector and provides courts to settle disputes that may arise between the parties to the contract. It is apparent that this contract or law must be so drawn that it is fair to all. In theory a law that imposes whimsical or arduous conditions on the vendor or producer will result in high prices to the consumer and one that does not protect the consumer's interests is likely to invite slovenly competition and therefore to fail to protect the market to the dealer. This raises the question, what is the object of a milk ordinance? It is this, to secure good clean milk for the consumer. Henderson has defined such milk as that which, being produced by practical dairymen from profitable cows, economically fed, housed in clean quarters, milked and attended by intelligent and well-paid milkers, is promptly cooled, kept uncontaminated till used, and is produced at a cost which admits of its being sold at a price which, while not prohibitive to the consumer, yet insures legitimate profit. The late G. M. Whitaker said that milk of good quality should be that with a proper amount of food material, no foreign substances, and no pathogenic bacteria and that it should come from clean cows, in clean surroundings. So there should be the following standards for milk; food standards, bacteriological standards, temperature standards and score-card standards.

Food standards would protect the public against adulteration and should keep off the market, milk of low food value. Bacterial standards serve as a check on the methods of production, but do not mean that milk attaining these standards is free from disease germs. Temperature standards should mean that the milk is kept as near 40°F. as possible. The score card should bring the dairy and dairyman to higher standards.

In addition to the postulates of Henderson and Whitaker the writer would add that the milk should come from healthy cows. That the milk of cows suffering from such diseases as anthrax, aphthous fever, cowpox and some other maladies should not be sold, probably all would agree, but probably some would permit the sale of pasteurized milk from animals that failed to give evidence of tuberculosis on careful physical examination. In regard to this matter it is best to be conservative but the dairy world is probably slowly working toward a great reduction in the amount of tuberculosis that will be tolerated in herds supplying the city market and possibly toward its ultimate extinction and it is the writer's belief that well-considered ordinances should exert pressure in this direction. Pasteurization acts as a palliative and not as a cure of the tuberculosis problem. When properly supervised, it offers a high degree of protection from the disease but it can never be regarded as

furnishing immunity from it and it is to be remembered that the more heavily the herds are infected the more likely is the protection offered by pasteurization to fail.

**Federal Control of the Milk Supply.**—The object being to secure for the public, milk of a character comparable to that indicated by Henderson and Whitaker the question arises whether control of the supply had best be undertaken by Federal, State or municipal authorities. Such power as the Federal Government possesses to compel milk dealers to produce safe clean milk is derived from the Food and Drug Act which is administered by the Bureau of Chemistry of the Department of Agriculture. Under this Act, the Department has power to request the Department of Justice to order prosecutions or seizures, only in the case of milk that enters into interstate commerce. In this work the Department does not set up standards but accepts those of the city into which the milk is being shipped across State lines. The Bureau of Chemistry, which has only a limited number of inspectors, does most of its work by coöperating with local authorities in the case of milk produced across a State line. When milk is found to be adulterated, it is, of course, seized. When indications are found that the milk is not properly produced, and is likely to become dangerous, the dairyman is warned to clean up and is shown how to improve his milk. If he fails to act on this warning, prosecution follows.

The Food and Drug Act applies to milk imported to the United States from foreign countries and according to its provisions the milk must conform to the standards of the nation from which it originates as well as to those of the United States. Dairy products which do not meet these standards are denied entry. The U. S. Department of Agriculture and the health officials of Canada coöperate in the attempt to secure the production and shipment of sanitary milk. Producing dairies must receive a well-balanced score of 50 on the basis of 100 possible points. To secure this score a dairy must meet certain Canadian requirements as to sanitation and handling of the milk, that are very similar to those that would be required to make such a score on the "official" score card in use in the United States. Furthermore, the milk must neither be misbranded nor adulterated within the meaning of the Act. Milk that meets Canadian requirements also meets those of the United States.

Such is the statement of the Department of Agriculture with reference to its own work. Evidently the Department has no jurisdiction over intrastate milk business and it is patent that a bureau with a limited number of inspectors can exercise only a nominal control over the great bulk of milk that enters into interstate commerce. Nevertheless the Department has done important work in studying conditions that obtain in particular districts and in assisting local authorities of cities receiving considerable quantities of milk from extrastate sources to increase the

cleanliness and stop the adulteration of such milk. In campaigns to improve such supplies the effort is made to teach dairymen better methods of production.

**State Control of the Milk Supply.**—It has been mentioned that, in Idaho, Montana and Iowa, control of the milk supply is exercised solely by the State which acts through variously constituted State boards or a State Dairy Commissioner. None of these States have large cities, consequently the regulation of the milk supply presents a somewhat different problem than in those States with large urban populations that are supplied by a specialized highly organized milk industry. Control of the milk supply may be put in the hands of the State for the good reason that the interests of the people and the industry are best served by a moderate amount of supervision mostly of an advisory character or for the unworthy one that the granger element wishes to keep cities from enacting milk ordinances that dairymen regard as inimical to their interests. In many States, as for instance New York, New Jersey and Illinois, the State Boards of Health maintain laboratories and a force of inspectors in the effort to improve both city milk supplies and dairy manufactures and often pay particular attention to the milk supplies of the smaller cities because their purity is commonly inadequately protected.

Sanitarians are not agreed as to the wisdom of State control of the milk supply. The magnitude of the problem is an all but insuperable obstacle to dealing with it successfully in this manner. There are thousands of dairies in a State and to inspect them so often as to be assured that the ordinary precautions that are known to be essential to the production of clean milk are employed would require a far larger force of inspectors than any State has ever contemplated employing. Some of those most experienced in the enforcement of pure food laws are convinced that the skimming and watering of milk can be kept down only by sampling and analyzing the milk of the different dealers so frequently that the dishonest ones will not care to take the risk of being detected in fraud. That sort of supervision may be necessary with city milk supplies but it would probably be unwise and certainly would be impossible to attempt to maintain the milk standards of the entire State in this way. These officials point out that the efforts of the States to eradicate tuberculosis by legislation have not been conspicuously successful. Therefore, they believe that it is futile for the State to attempt to exercise even so much as a supervisory control of the milk supply. They would have it do a minimum of analytical work and inspection and confine its efforts toward improving the milk supply, to utilizing its numerous avenues of publicity to educate the citizens on all phases of the milk question and in assisting municipalities to draw up sensible workable ordinances. These officials regard the control of the milk supply as a local question to be worked out by local officers and dairymen.

**Municipal Control of the Milk Supply.**—Local control of the milk supply becomes increasingly difficult as a city grows. A village or small city can, if it will, exercise successful supervision over the dairies that supply it. So long as they are few in number and near at hand the health officer can keep in close contact with the producers and the dairymen themselves have personal interest in their customers but when the producers become so many that they are in a sense strangers to the health office and their trade and when much of the milk comes from a distance, control becomes general instead of personal and loses much of its effectiveness. Some cities grow to such size that close inspection of the dairies is not to be thought of because of its prohibitive expense. Thus, New York City in 1912 consumed 2,500,000 qt. of milk daily. It was produced by about 350,000 cows on 44,000 farms in six States and 127,000 people were estimated to be engaged in the daily handling of the milk. In 1915 over 80 per cent. of the milk came from points over 200 miles from the city and the longest haul was 460 miles.

**Control of the Milk Supply by the Contractor.**—Reflection on such figures as these suggests inspection of dairies by the contractor, as helpful and necessary. The law usually makes a dealer in foods responsible for their quality. So, as a business proposition it is good policy for a milk dealer to inspect the dairy farms that supply him. Indeed, some profess to believe that ultimately the dealer will assume the responsibility of furnishing adequate inspection and that official inspection will become less important. However, official supervision of the dealer's inspection will probably always be necessary because in most dairy districts there is competition for the farmer's milk which tends to make the dealer adopt lenient standards of inspection in order to hold the farmer's business. Indeed, some authorities are inclined to believe that one of the first moves in improving the quality of milk furnished any community should be to secure an abundant supply for, so long as there is only enough barely to meet the needs of the community, the dairyman who produces inferior milk can market it.

So then, while both Federal and State Governments exercise control over the milk supply, each community is largely dependent on its own initiative and energy for securing an adequate and safe supply of milk. A milk policy must be adopted and this policy must be stated in the form of an ordinance.

**Milk Codes.**—The variety in milk ordinances is almost endless but they can be grouped in two classes, namely: (1) those that, though they conform to legal usage, are verbose, vague in meaning and provide inadequate or unworkable standards; and (2) those that are concise, easily interpreted, in accord with modern standards and adapted to the needs of the community that is to use them. The cardinal points to be provided for are that: (1) An officer or board shall be designated to enforce the ordinance and be

clothed with the necessary authority and provided with the necessary funds to do it. (2) Everyone engaged in producing or vending milk shall be required to take out a permit or license therefor which permit shall be non-transferable and revokable by the officer or board, if the provisions of the ordinance are not complied with. (3) There shall be temperature standards governing the temperature at which milk shall be held on the farm, in transit to the city, in storage and on delivery wagons in the city. (4) There shall be chemical standards which may well conform to those established by the Federal Government or by the State. (5) Bacteriological standards may be established. If they are, care should be taken on the one hand that they are not so low as to be practically impossible to attain and on the other that they are not so high as to be farcical. (6) There should be standards for pasteurization. These should specify the kinds of pasteurization that are allowable, the temperatures and period of heating of the milk and should require the use of automatic recording thermometers. Proper labeling of pasteurized milk should be insisted on which means that the date of pasteurization, the degree of temperature used and the time of exposure thereto should be plainly stated on the bottle. Repasteurization of milk for sale should be prohibited. (7) The policy with regard to the control of bovine tuberculosis should be embodied in the ordinance. (8) The sanitation of dairies, country and city milk plants and stores where milk is sold should be covered. Provision should be made for the use of score cards and the sediment test. (9) For the protection of consumers some ordinances establish the limit of tolerance for milk bottles and make it a finable offense to use them as containers for anything but milk. In a few cities the bottles are required to be marked with the dealer's name and dealers are prohibited from using one another's bottles.

**The Grading of Milk.**—Whether a system of grading milk shall be provided by the ordinance must receive careful consideration. The first step toward grading was a resolution, not having the effect of law, of the New York Board of Health advising that all milk for drinking should be either boiled or pasteurized and suggesting that milk should be graded into (1) milk for babies to drink; (2) milk for adults to drink; and (3) milk for cooking only. This is still the broad basis for grading milk. In 1911 the Board announced that after Jan. 1, 1912, all except specially high-grade milk be pasteurized and later in 1911 as a result of a joint conference with milk dealers, the New York Milk Committee and certain physicians established the following grades for milk:

1912

Grade A.

1. Certified or guaranteed.
2. Inspected raw.

    Dairies must attain a score of 25 on equipment and 50 on methods.

The bacterial count of the milk must not exceed 60,000 per cubic centimeter before pasteurization nor 50,000 when delivered to consumer.

Grade B.

1. Selected raw.

   Dairies must score 25 on equipment and 43 for methods.

   The bacterial count shall not be excessive.

2. Pasteurized.

   No requirements either as to dairy score or bacterial counts.

Grade C.

For cooking only.

At first it was permissible to sell such milk in a raw state but later it was made requisite to pasteurize it; however, no standards were set for it.

In 1913 as the result of a milk-borne typhoid-fever epidemic, grade B raw milk was abolished and bacterial standards for all the grades of milk were established. Grade A was simplified and the pasteurization of cream and all milk, except Grade A, was required. The grading in use in 1915 was the following:

1915

Grade A.

1. Raw. The cows must pass the tuberculin test.

   Dairies must attain a score of 25 on equipment and 50 on method.

   The bacterial count of the milk must not exceed 60,000 per cubic centimeter when delivered to consumers.

2. Pasteurized.

   Dairies must attain a score of 25 for equipment and 43 for methods.

   The bacterial count of the milk must not exceed 200,000 per cubic centimeter before pasteurization nor 30,000 per cubic centimeter when delivered to the consumer.

Grade B.

Dairies must attain a score of 20 on equipment and 35 on methods.

The bacterial count of the milk if pasteurized in the country must not exceed 300,000 per cubic centimeter, or if pasteurized in the city 1,500,000 per cubic centimeter before pasteurization and the bacterial count of neither one must not exceed 100,000 per cubic centimeter when delivered to the consumer.

Grade C.

Pasteurized.

Dairies must attain a total score of 40 and the bacterial count after pasteurization must not exceed 300,000 per cubic centimeter.

Grade A milk which is intended for children requires the most supervision; the necessary distinction as to that grade is obtained by forbidding grade A plants to handle milk of lower grade.

With regard to grade B milk it should be said that few of the dairies are scored at the present time and that its fitness for pasteurization and use is determined by the bacterial count. It is the milk that is used by the great majority of the people of New York City.

Objections that are urged to establishing a system of grading are that: (1) These grades which are practically the only ones in use, are based on insufficient experimental data and are at best merely tentative. (2) There should be but one grade of milk and that should be of sufficiently good quality to pass all reasonable tests of healthfulness. (3) The attempt to maintain more than one grade of milk will confuse the public and impose additional costs on the dealers who will find it more difficult to conduct a profitable business working under a system of grades than under a single standard of quality. (4) The poor will be the purchasers of the inferior milk. (5) The public is not educated up to paying for the higher grades of milk. (6) The grading of milk offers opportunity for collusion between the dealer and the Board of Health.

In favor of the grading system it is urged: (1) All food products except milk are sold in the market according to quality or grade and there is a clear demand by the public for three grades of milk. (2) Milk that is handled with superior care should not be forced to compete with ordinary milk. (3) While there has been a notable improvement in the quality of milk sold in the last decade the improvement proceeds too slowly for the well-being of both the consumer and the industry and it can best be accelerated by the establishment of grades. (4) The contention that the poor will get all the inferior milk is without merit for they get it under a non-graded system. The tendency of grading is to raise the average market quality which is a benefit in which the poor share. (5) There is no evidence in the experience of New York dealers that the grading system reduced profits. (6) While it is true fraudulent practices may creep into the grading system, so they may in any system of milk control and there is no reason to suppose that the honest elements of society will be any less likely to be successful in controlling them under the grading system than under any other.

The grading system has attained enough success in New York to make it certain that in the future some system of grading will be widely used. The experience of New York City and experiments that are designed to get data for more rational grading than has yet been possible are being watched closely. Till more information is available the grading of milk should be attempted very cautiously. It is the opinion of the Committee on Improvement of Milk Supplies of the International Milk Dealer's Association that the discussion of the establishment of the purchase of cream on a basis of quality for the manufacture of butter in the States of Iowa, Missouri, Kansas, Nebraska, Minnesota, Wisconsin, Michigan, Illinois and Ohio, has paved the way for the advancement of milk grading.

**The Milk Code Should be Suited to the Community.**—It is highly important that the ordinance shall be suited to the community which is to use it. The mistake is often made of copying the ordinance of a city

that by long effort has improved its sources of supply, its milk plants and stores where milk is sold, to the point where they can work without hardship under a rather stringent law, in a city that is just beginning a campaign for clean milk in the midst of crude conditions. The result is that the dairy industry is financially unable to meet the newly imposed regulations and the effort to improve the supply comes to naught. There is the same result when the attempt is made to thrust the ordinance of a big city on a small one. The writer once heard an enthusiastic physician advocate, for a city of 40,000 inhabitants, an ordinance that was strikingly similar to that of New York City.

It ought to be unnecessary to state that an ordinance is stillborn unless officers are appointed and money appropriated to enforce it but those who are secretly hostile to ordinances they dare not openly oppose often nullify them by neglecting to provide these very things.

**Type of Ordinance Proposed by Whitaker.**—As a satisfactory type of city milk ordinance, the International Association of Dairy and Milk Inspectors has endorsed that outlined by the late George M. Whitaker which follows:

"An Act (Ordinance) to Regulate the Sale of Milk in ——

SECTION 1

The Requirement

No person, himself, or by his servant or agent, or as the servant or agent of another, shall sell or deliver or have in his possession or custody with intent to sell or deliver:

1. Milk to which water or any foreign substance has been added.
2. Milk which has been wholly or partially skimmed.
3. Milk not of standard quality.
4. Milk concerning which any misrepresentation has been made.
5. Milk produced by diseased cows or by cows that have been fed unwholesome food or contaminated water, or
6. Milk that has been produced, stored, handled or transported in an improper, unclean or insanitary manner.

SECTION 2

Definitions and Exceptions

For the purpose of this Act the word "person" shall be construed to mean individual, partnership or corporation; the word "milk" shall mean milk, cream, or evaporated or condensed milk, so far as may be applicable; the expression "milk not of standard quality" shall mean milk having less than 8.5 per cent. of solids-not-fat and less than 3.25 per cent. of butterfat, and cream having less than 18 per cent. of butterfat. Skim-milk having less than 9.3 per cent. of milk solids exclusive of fat shall be considered adulterated.

Nothing in this Act shall be construed to prohibit the sale of skim-milk or of understandard milk if the receptacle containing the same and from which it is

sold is plainly marked with the word "skim-milk" in the case of skim-milk or with the percentage of butterfat contained therein in the case of understandard milk or cream. The aforesaid words and figures shall be distinct and conspicuous; they shall be permanently attached to the aforesaid container above the center of the same; they shall be of uncondensed gothic style and their length shall be at least one-tenth of the height of the container on which they are placed; when glass bottles are used the required marks shall be blown into the side of the bottle and also distinctly printed on the cap or cover of the same.

Nothing in this (Act or Ordinance) shall be construed to prevent the sale of modified milk in bottles, each holding a single feeding, into the side of which the name of the person who manufactured or prepared the same has been blown together with the words "Modified Milk." Nothing in this (Act or Ordinance) shall apply to evaporated or condensed milk contained in hermetically sealed packages labeled distinctly with the name of the manufacturer or person who prepared or put it up and the brand under which it is made or sold. Certified milk shall mean milk produced under the regulations and supervision of a regular county medical society acting through a committee or commission which has certified that its requirements have been complied with.

For the purpose of this Act, cows which react to the tuberculin test shall be considered diseased; milk produced at a dairy which scores (on the National Dairy Division "official" score card) below 50 and milk sold by or from a city milk plant which scores (on the National Dairy Division "official" score card) below 70 shall be considered as produced or handled in an improper, unclean and insanitary manner. Milk from a cow 2 weeks before calving and 5 days after, shall be regarded as insanitary. For the purpose of this Act, milk with a temperature above 50°F., or having more than 500,000 bacteria per cubic centimeter, shall be regarded as insanitary. When milk is bought by the quart or gallon, the gallon of 231 cu. in. and the quart of 57.75 cu. in. shall be standard and shall be so understood.

## Section 3

### Licenses

Every person before selling milk or offering it for sale, or before conveying milk in carriages or otherwise for the purpose of selling or delivering it in the city of ——— shall be licensed by the chief of the Milk Inspection Bureau, hereinafter provided for, to sell milk within the limits thereof, and shall pay —— cents to the use of the city. The license fee shall be paid to the chief of the Milk Inspection Bureau and by him turned over to the city treasurer. Licenses shall be issued only in the name of the owners of carriages or other vehicles, or stores or booths. They shall for the purpose of the act be conclusive evidence of ownership of the business, and shall contain a serial number and the name, residence and place of business of the licensee. Each licensee before engaging in the sale of milk shall cause his name and number of his license to be conspicuously posted in his place of business and shall cause his name, the number of his license, and his place of business, to be legibly placed on each side of all carriages or vehicles used by him in the conveyance and sale of milk. The application shall give the name of all drivers and other persons employed by the applicant in conveying or selling milk. It shall also give the names of all persons from whom the appli-

cant is at the time purchasing or receiving milk, their residence and post-office address, and such detailed information as to the condition of their cows and premises and their methods as the aforesaid Chief may require. The application shall contain an agreement that the Chief of the Milk Inspection Bureau, his deputies and assistants shall have the right to inspect the cows, premises and methods of said producer.

Holders of licenses shall promptly notify in writing the chief of the Milk Inspection Bureau of any change of drivers or other employees or of any change in the source of their milk supply. Each license shall be granted on the condition that it is subject to suspension for violation of any provision of this (Act or Ordinance) or of any regulation thereunder. All licenses shall be renewed on or before the first day —— of each year.

## Section 4

### Bureau of Milk Inspection

A milk inspection Bureau of the Health Department is hereby created. The (Board of Health or Health Commission) shall (annually or biennially) appoint a Chief of the Milk Inspection Bureau at a salary of $———. (Make provision for assistants, chemist, bacteriologist, etc., if place is large enough.)

The aforesaid Chief shall enforce the provisions of this (Act or Ordinance) and regulations thereunder, under the general direction of Board of Health (or Health Commission) and be responsible to (it or him) for the conduct of his office. The chief of the Milk Inspection Bureau by himself or a duly authorized deputy or assistant shall at least four times each year inspect all animals, stables, milk rooms, vehicles, places of business, shipping stations and other buildings or places used in the production, handling, transportation or storage of milk for sale in the city of which he is officer, using the score card of the Dairy Division of the Bureau of Animal Industry of the United States Department of Agriculture (the "official" score card), and rating the dairies thereon. He shall also investigate the health of employees and attendants handling the milk supply. He shall take samples of milk for chemical and bacteriological examination. For the purpose of enforcing this law the aforesaid Chief and assistants may enter all aforesaid places and buildings used in the production and handling of milk for the city of which he is an officer; he shall have access to all animals producing milk for said city and to all vessels and utensils used in the production, preparation for market, and sale of such milk; and he shall be allowed to take samples of milk on offering payment therefor. He may revoke or suspend the licenses heretofore provided for, for violation of this law or of the regulations made thereunder. The aforesaid chief of the Milk Inspection Bureau shall annually test or cause to be tested with tuberculin, all cows furnishing milk for the city of ————.

## Section 5

### Miscellaneous

A person suffering from any contagious disease, or one in whose residence, or among whose associates, any contagious or infectious disease exists, must keep away from cows, milk or milk utensils. When any person engaged in the production, storage or distribution of milk is suffering from any contagious or in-

fectious disease, or when such disease exists among his employees or their immediate associates, or within any building used in any way in the milk business, no milk shall be sold or delivered from such dairy or milk establishment, except by permission of and in the manner prescribed by the Board of Health. No person who has anything to do in the production or handling of milk shall enter any place where exists any contagious or infectious disease nor have any communication with any person who is an occupant of such infected places. Every producer who sells milk directly to the consumer shall promptly notify the Board of Health of any case of communicable disease among his employees, their immediate associates, or members of his family. Every milk producer who sells his product to a middleman for resale shall notify said dealer of the existence of any communicable disease as aforesaid and said dealer shall at once notify the Board of Health.

No milk shall be dipped from cans or poured into other vessels except in the regular milk room of a dairy plant. No milk shall be bottled upon any wagon.

Milk tickets shall be used but once.

No one shall deliver milk to or remove any milk bottle or receptacle from a dwelling where any contagious disease exists, until authorized by the Board of Health in the way prescribed by the Board.

No one shall place or permit to be placed in any vessel or utensil used in the production, sale or delivery of milk, any offal, swill, kerosene oil or other offensive material; nor shall he return or cause to be returned any milk can or bottle which is in an unclean or offensive condition.

The presence of a diseased animal in a herd from which milk is sold shall be *prima facie* evidence that the milk of the diseased animal is sold contrary to law.

The Board of Health (Health Commission) may make all necessary regulations for enforcing this (Ordinance or Act).

### Section 6

### Penalties

Whoever violates any provision of this Act (Ordinance) or any regulation made under its authority, and whoever hinders, obstructs or interferes with the Chief of the Milk Inspection Bureau or any of his inspectors or assistants in the discharge of their duty shall be punished by a fine of not less than \$—— or more than \$——."

**Type of Ordinance Proposed by the New York Milk Committee.**—The American Public Health Association, the American Medical Association, the Provincial Boards of Health of North America, and the American Veterinary Association have indorsed the Second Report of the Commission on Milk Standards of the New York Milk Committee. The report has not yet been indorsed by the International Association of Dairy and Milk Inspectors whose members have had more practical experience in the regulation of milk supplies than have the members of the associations that have approved it. Milk ordinances may be constructed in accordance with the principles of this report, which follows.

## Need of Milk Control

Proper milk standards, while they are essential to efficient milk control by public health authorities and have as their object the protection of the milk consumer, are also necessary for the ultimate well-being of the milk industry itself. Public confidence is an asset of the highest value in the milk business. The milk producer is interested in proper standards for milk, since these contribute to the control of bovine tuberculosis and other cattle diseases and distinguish between the good producer and the bad producer. The milk dealer is immediately classified by milk standards, either into a seller of first-class milk or a seller of second-class milk, and such distinction gives to the seller of first-class milk the commercial rewards which he deserves, while it inflicts just penalties on the seller of second-class milk. For milk consumers, the setting of definite standards accompanied by proper labeling makes it possible to know the character of the milk which is purchased and to distinguish good milk from bad milk. In the matter of public health administration, standards are absolutely necessary to furnish definitions around which the rules and regulations of city health departments can be drawn, and the milk supply efficiently controlled.

## Public Health Authorities

While public health authorities must necessarily see that the source of supply and the chemical composition should correspond with established definitions of milk as a food, their most important duty is to prevent the transmission of disease through milk. This means the control of infantile diarrhea, typhoid fever, tuberculosis, diphtheria, scarlet fever, septic throat infections, and other infectious diseases in so far as they are carried by milk.

## Septic Sore Throat

Septic sore throat deserves special mention because of the frequency in recent years with which outbreaks of this disease have been traced to milk supplies. The suggestion has been made that the infection of the milk is due to udder infection of the cow and on the other hand it has been suggested that it is due to contact with infected persons. The uncertainty cannot be dispelled until cases of septic sore throat are regularly reported and tabulated by public health authorities. The commission, therefore, recommends that public health authorities make septic sore throat a reportable disease.

## Economic Problem

The commission recognizes the magnitude of the milk industry, and that the improvement of milk supplies is primarily an economic problem. The success achieved by the experiment in milk production, which has been carried out on a very large scale by the New York Dairy Demonstration Co., is an illustration of the fact that an extra price or premium paid to the producer for cleanliness and care will bring results far more quickly and certainly than instructions or official inspection. But while the basic problem is economic, and must eventually be solved by commerce, public health authorities must show the way and must establish standards and regulations in the interest of consumers, the value of which even the consumers themselves often fail to appreciate.

A prime requisite of effectiveness is that local milk laws shall not exceed sanitary limitations. The commission has not entered into a discussion of fundamental State laws, but it recommends that State laws be amended wherever necessary in order that every municipality may have the legal right to adopt whatever ordinances it sees fit for the improvement of the milk supply. The commission advocates that local health laws be carefully drawn with regard to their legality under the general laws of the localities to which they apply, since a decision against a milk law in one locality is liable to be used as a precedent against milk laws elsewhere.

## Standard Rules and Regulations

The commission has drawn up a set of standard rules and regulations for the control of milk. These are the result of a study of the printed rules and regulations of the cities of the United States and of foreign countries and represent an immense amount of work on the part of the special committee of the commission to which the task was assigned. Some communities are in a position to adopt all of these rules and regulations at the present time, while other communities will be obliged to adopt a few rules at a time as public sentiment and local conditions warrant. It is realized that some of the rules may have to be modified to meet local conditions. It seems wise to the commission to divide the regulations into two parts: First, requirements, under which head are set down those provisions which are so fundamentally necessary that no community is justified in compromising on them; second, recommendations, under which head are set down provisions which are necessary for a good milk supply, but on which there can be a certain amount of latitude for compromise by those communities in which public sentiment is not ready to support more than a moderate degree of protection of human life.

## Administrative Equipment

Another prime requisite is that the administrative departments shall be adequately equipped with men, money, and laboratory facilities. In smaller communities coöperation between local boards of health to the extent of exchanging reports would eliminate much duplication. Where a community cannot maintain a laboratory it can enter into laboratory arrangements with other communities, and several can combine in the use of a common laboratory. Much of the expense of tuberculin testing can be borne by the National and State Governments. The commission is of the opinion that results cannot be expected from laws where there is not sufficient appropriation and where there is no machinery for their enforcement. On this subject the commission passed a resolution as follows:

Whereas the appropriations generally made for the purposes of carrying on laboratory analyses of milk are now in most cases entirely inadequate: Therefore be it

*Resolved,* That this commission recommends for the consideration of the authorities concerned an appropriation of funds commensurate with the importance of laboratory methods, which are of paramount importance in the hygienic control of the milk supply.

## Grading of Milk

There is no escape from the conclusion that milk must be graded and sold on grade, just as wheat, corn, cotton, beef, and other products are graded. The

milk merchant must judge of the food value and also of the sanitary character of the commodity in which he deals. The high-grade product must get a better price than at present. The low-grade product must bring less. In separating milk into grades and classes the commission has endeavored to make its classification as simple as possible and at the same time to distinguish between milks which are essentially different in sanitary character.

In general two great classes of milk are recognized, namely, raw milk and pasteurized milk. Under these general classes there are different grades, as indicated in the report of the committee on classification.

### Pasteurization

While the process of pasteurization is a matter which has attracted a great deal of attention in recent years, the commission has not entered into any discussion of its merits or demerits, but has given it recognition in its classification as a process necessary for the treatment of milk which is not otherwise protected against infection.

The commission thinks that pasteurization is necessary for all milk at all times, excepting grade A, raw milk. The majority of the commissioners voted in favor of the pasteurization of all milk, including grade A, raw milk. Since this was not unanimous the commission recommends that the pasteurization of grade A, raw milk, be optional.

The process of pasteurization should be under official supervision. The supervision should consist of a personal inspection by the milk inspector; the inspections shall be as frequent as possible. Automatic temperature regulators and recording thermometers should be required and the efficiency of the process frequently determined by laboratory testing.

The destruction of the chemical constituents of milk by heat occurs at higher temperatures than those necessary for the destruction of the bacteria of infectious diseases transmissible by milk. (See Fig. 41, p. 279.)

The commission passed a resolution regarding the temperature of pasteurization as follows:

That pasteurization of milk should be between the limits of 140°F. and 155°F. At 140°F. the minimum exposure should be 20 min. For every degree above 140°F. the time may be reduced by 1 min. In no case should the exposure be for less than 5 min.

In order to allow a margin of safety under commercial conditions the commission recommends that the minimum temperature during the period of holding should be made 145°F. and the holding time 30 min. Pasteurization in bulk when properly carried out has proven satisfactory, but pasteurization in the final container is preferable.

It is the sense of the commission that pasteurization in the final container should be encouraged.

### Labeling and Dating of Milk

The commission voted that all milk should be labeled and marked with the grade in which it is to be sold. In dating milk uniform methods should be adopted for all grades of both raw milk and pasteurized milk, both using the day of the week or both using the day of the month. All milk should be dated uni-

formly with the date of delivery to the consumer. Raw milk should not be dated with the date of production while pasteurized milk is dated with the date of pasteurization, since this places certified milk at a disadvantage by making it possible for pasteurized milk of a lower grade to carry a later date. The stamping on the label of the day of the week is sufficient for dating.

### Bacteria

The subject of bacteria in milk received more attention than any other matter brought before the commission. The commission recognizes that bacteria in milk in the majority of instances indicate dirt, or lack of refrigeration, or age, while in the minority of instances the bacteria of disease may be present. The routine laboratory methods for examining milk have as their purpose only the control over dirt, refrigeration, and age, and it is a rare thing for a laboratory to undertake the examination of milk for the bacteria of disease because of the extreme difficulties in detecting them. The more efficacious method of protecting milk from infection by the bacteria of human contagion is by medical, veterinary, and sanitary inspection, and by pasteurization. Milk with a high bacteria count is not necessarily harmful, but when used as a food, particularly for children, is a hazard too great to be warranted. Milk with a high bacteria count, therefore, should be condemned. Milks with small numbers of bacteria are presumed to be wholesome, unless there is reasonable ground for suspecting that they have been exposed to contagion.

### Bacterial Standards

The commission recognizes the difficulty in interpreting bacteria counts. At times misleading conclusions have been drawn from such counts. In establishing the bacterial standards for a city it is always necessary to take into consideration the necessary age of the milk and in lesser measure the distance hauled and methods employed in its hauling. It will always be possible for a community which consumes milk produced on its own premises, or within 12 hr. of its production, to insist upon and maintain a lower bacterial standard than can one where the milk is hauled many miles into town in a wagon, to be consumed within 24 hr. after it is produced. In like manner this second type of city can always maintain a lower bacterial standard than a city where the general milk supply is hauled by railroad long distances and is several days old when consumed. In drawing conclusions as to the relative efficacy of milk control in cities comparisons must be made between cities of the same class.

The commission deems it of the utmost importance that some standard method should be adopted for estimating and comparing the bacterial character of mliks, since by this means only is it possible to grade and classify milks and to enforce bacterial standards. There is much diversity of opinion as to the best method of valuing bacteria counts. The average of a series gives results which are misleading about as frequently as otherwise. In the average a single high figure may unduly overbalance a large number of exceedingly low counts. There are objections to the use of the "median" or middle number when the counts are arranged in order of size, for the reason that the middle figure does not distinguish between two groups in one of which there may be some very high counts above the median and in the other of which there are none. The method of dividing

results into groups as recommended by the American Public Health Association, while a step in the right direction, is cumbersome and does not clearly indicate whether or not a milk conforms to a given bacterial standard.

The commission passed a resolution at its last meeting regarding the number of bacterial tests necessary to determine the grade into which a milk falls, as follows:

That the grade into which a milk falls shall be determined bacteriologically by at least five consecutive bacteria counts taken over a period of not less than one week nor more than one month, and at least 80 per cent. (four out of five) must fall below the limit set for the grade for which the classification is desired.

On the subject of laboratory examinations of milk for bacteria the commission passed the following resolutions:

1. That the interests of public health demand that the control of milk supplies, both as to production and distribution, shall include regular laboratory examinations of milk by bacteriological methods.

2. That among present available routine laboratory methods for determining the sanitary quality of milk the bacteria count occupies first place.

3. That bacteriological standards should be a factor in classifying or grading milks of different degrees of excellence.

4. That in determining the grade or class of a raw milk the specimen taken for bacteriological examination should be of milk as offered for sale.

5. That there should be bacteriological standards for pasteurized milk which should require laboratory examination of samples immediately before pasteurization as well as of milk offered for sale.

6. That the bacteria count of milk indicates its quality and history as it is modified by contamination, handling, dirt, temperature, or age. A high count indicates the necessity of investigation and inspection.

7. That there be adopted as standards for making the bacteria count the standard methods of the American Public Health Association, laboratory section, recommending, however, the following amendments:

A. That the culture medium used for testing milk be identical in its composition and reaction with the culture medium used for the testing of water provided in the standard methods of water analyses of the American Public Health Association.

B. That incubation of plate cultures be made at 37°C. for 48 hr.

The bacterial standards given in the report are the work of a special committee of bacteriologists who considered all of the bacterial standards now in use. It is believed that the standards suggested are fair and wise and give full consideration to the state of the industry and of public health control. The commission believes that the adoption and enforcement of these bacterial standards will be more effective than any other one thing in improving the sanitary character of public milk supplies. The enforcement of these standards can be carried out only by the regular and frequent laboratory examinations of milks for the numbers of bacteria they may contain.

### Chemical Standards

The chemical standards suggested are the work of a special committee, composed of chemists, which has carefully considered the natural composition of milk and the Federal and State standards already established. The standard of 3.25 per cent. fat and 8.5 per cent. solids, not fat, here proposed is in accordance

with the recommendations of the Association of Official Agricultural Chemists and has been adopted by the United States Department of Agriculture and by a larger number of States than has any other standard. The simplification of the Babcock test makes the determination of fats and solids-not-fat an easy procedure quickly applied. Such chemical examinations of milk can be readily adopted and executed by any health-board laboratory at a very moderate expense. It is believed that such chemical standards as are suggested will inflict no real hardship on the milk producers of this country and that the provision regarding substandard milks is a liberal one.

## Microscopic Examination of Milk

Because of studies which have been made during the past year the commission thinks it wise to omit temporarily any definite statement on the subject of microscopical examination of milk, and the determination of pus and bacteria by sedimentation methods, until further studies have been made. A special subcommittee has been appointed for this purpose which will make studies during the present year and the commission will take action on this matter at one of its later meetings.

## Mislabeling

The commission resolved that the sale of milk which is mislabeled or misbranded shall be punished by suitable penalties.

## Publicity

The commission fully considered the matter of the publication of laboratory examinations of milk by city and town health authorities. When proper standards and regulations are established and adequate facilities furnished for laboratory work, it is believed that the laboratory tests will give an index of the character of the milk delivered to the public by milk sellers which is entirely fair and impartial. There can be no objection to publicity under such circumstances. It is an advantage to the seller of high-grade milk. It is an advantage to the consumer who desires to select a high-grade milk. It has much educational value both to producer and consumer. Therefore the commission recommends "that the reports of laboratory analyses of milk made by departments of health be regularly published."

## Medical Inspection

It is the sense of the commission that the medical inspection of dairy employees should be emphasized in all ways possible.

## Milk Dealer's License

The commission resolved that a dealer shall be required to have a permit or license to sell any grade or class of milk and to use a label for such class or grade. Such permit or license shall be revoked and the use of the label forbidden when the local health authorities shall determine that the milk is not in the class or grade designated.

### Designation of Grade

The commission resolved that the grade of milk shall be designated by letter. It is the sense of the commission that the essential part is the lettering and that all other words on the label are explanatory.

In addition to the letters of the alphabet, used on caps or labels, the use of other terms may be permitted so long as such terms are not the cause of deception.

Caps and labels shall state whether milk is raw or pasteurized. The letter designating the grade to which milk belongs shall be conspicuously displayed on the caps of bottles or the labels on cans.

### Classification of Milk

It was resolved that the classification of milk contained in the first report of the commission be amended as follows:

Milk shall be divided into three grades, which shall be the same for both large and small cities and towns, and which shall be designated by the first three letters of the alphabet. The requirements shall be as follows:

#### GRADE A

*Raw milk.*—Milk of this class shall come from cows free from disease as determined by tuberculin tests and physical examinations by a qualified veterinarian, and shall be produced and handled by employees free from disease as determined by medical inspection of a qualified physician, under sanitary conditions such that the bacteria count shall not exceed 100,000 per cubic centimeter at the time of delivery to the consumer. It is recommended that dairies from which this supply is obtained shall score at least 80 on the United States Bureau of Animal Industry score card.

*Pasteurized milk.*—Milk of this class shall come from cows free from disease as determined by physical examinations by a qualified veterinarian and shall be produced and handled under sanitary conditions such that the bacteria count at no time exceeds 200,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacteria count shall not exceed 10,000 per cubic centimeter at the time of delivery to the consumer. It is recommended that dairies from which this supply is obtained should score 65 on the United States Bureau of Animal Industry score card.

The above represents only the minimum standards under which milk may be classified in grade A. The commission recognizes, however, that there are grades of milk which are produced under unusually good conditions, in especially sanitary dairies, many of which are operated under the supervision of medical associations. Such milks clearly stand at the head of this grade.

#### GRADE B

Milk of this class shall come from cows free from disease as determined by physical examinations, of which one each year shall be by a qualified veterinarian, and shall be produced and handled under sanitary conditions such that the bacteria count at no time exceeds 1,000,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacteria count shall not exceed 50,000 per cubic centimeter when delivered to the consumer.

It is recommended that dairies producing grade B milk should be scored and that the health departments or the controlling departments, whatever they may be, strive to bring these scores up as rapidly as possible.

### GRADE C

Milk of this class shall come from cows free from disease as determined by physical examinations and shall include all milk that is produced under conditions such that the bacteria count is in excess of 1,000,000 per cubic centimeter.

All milk of this class shall be pasteurized, or heated to a higher temperature, and shall contain less than 50,000 bacteria per cubic centimeter when delivered to the customer. It is recommended that this milk is used for cooking or manufacturing purposes only.

Whenever any large city or community finds it necessary, on account of the length of haul or other peculiar conditions, to allow the sale of grade C milk, its sale shall be surrounded by safeguards such as to insure the restriction of its use to cooking and manufacturing purposes.

### Classification of Cream

Cream should be classified in the same grades as milk, in accoradnce with the requirements for the grades of milk, excepting the bacterial standards which in 20 per cent. cream shall not exceed five times the bacterial standard allowed in the grade of milk.

Cream containing other percentages of fat shall be allowed a modification of this required bacterial standard in proportion to the change in fat.

### Chfmical Standards

*Cow's Milk.*—Standard milk should contain not less than 8.5 per cent. of milk solids-not-fat and not less than 3.25 per cent. of milk fat.

*Skim Milk.*—Standard skim milk should contain not less than 8.75 per cent. of milk solids.

*Cream.*—Standard cream contains not less than 18 per cent. of milk fat and is free from all constituents foreign to normal milk. The percentage of milk fat in cream over or under that standard should be stated on the label.

*Buttermilk.*—Buttermilk is the product that remains when fat is removed from milk or cream, sweet or sour, in the process of churning. Standard buttermilk contains not less than 8.5 per cent. of milk solids. When milk is skimmed, soured, or treated so as to resemble buttermilk, it should be known by some distinctive name.

### Homogenized Milk or Cream

The commission is of the opinion that in the compounding of milk no fats other than milk fats from the milk in process should be used and that no substance foreign to milk should be added to it. The commission is opposed to the use of condensed milk or other materials for the thickening of cream unless the facts are clearly set forth on the label of the retail package. Regarding the process of homogenizing, the commission resolved as follows:

That homogenized milk or cream should be so marked, stating the percentage of fat that it contains.

### Adjusted Milks

On the question of milks and creams in which the ratio of the fats to the solids-not-fat has been changed by the addition to or subtraction of cream or milk fat the commission has hesitated to take a position. On the one hand they

are in favor of every procedure which will increase the market for good milk and make the most profitable use of every portion of it. On the other, they recognize the sensitiveness of milk, the ease with which it is contaminated, and the difficulty of controlling, standardizing, skimming, homogenizing, souring, etc., so that contaminations do not occur and inferior materials are not used. On this subject the commission passed a resolution presented by a special committee as follows:

Milk in which the ratio of the fats to the solids-not-fat has been changed by the addition to or subtraction of cream should be labeled "adjusted milk;" the label should show the minimum guaranteed percentage of fat and should comply with the same sanitary or chemical requirements as for milk not so standardized or modified.

### Regulation of Market Milk on Basis of Guaranteed Percentage Composition

1. Sellers of milk should be permitted choice of one of two systems in handling market milk. Milk can be sold, first, under the regular standard, or, second, under a guaranteed statement of composition.
2. Any normal milk may be sold if its per cent. of fat is stated. In case the per cent. of fat is not stated, the sale will be regarded as a violation unless the milk contains at least 3.25 per cent. of milk fat.
3. As a further protection to consumers, it is desirable that when the guaranty system is used there be also a minimum guaranty of milk solids-not-fat of not less than 8.5 per cent.
4. Dealers electing to sell milk under the guaranty system should be required to state conspicuously the guaranty on all containers in which such milk is handled by the dealer or delivered to the consumer.
5. The sale of milk on a guaranty system should be by special permission obtained from some proper local authority.

### Penalty

Every milk ordinance should contain a penalty clause.

### Extension Work

The commission indorsed the efforts of the New York Milk Committee to obtain funds for the formation of a bureau of extension work, such bureau to act as a collecting station for information regarding standards and regulations as to milk adopted by cities and towns in the United States. The bureau should also furnish information to such cities and towns as appeal for aid in the adoption of milk standards and should conduct a constructive program by placing in the field a man who would visit communities interested in establishing milk standards; and it may use the members of the commission on milk standards for carrying on the work of the bureau so far as possible in their own localities.

# APPENDIX

## Standard Rules for the Production, Handling, and Distribution of Milk

As a basis for the promulgation of rules and recommendations governing the production, handling, and distribution of milk, it is recognized that we have to deal with two kinds of milk, raw and pasteurized, although there may be several grades of each of these two kinds. In order for any grade to be safe, it is recommended that the regulations herein set forth under the heading "Requirements" should be enforced. The regulations herein set forth under the heading "Recommendations" should be adopted wherever practicable as a means of improving the milk supply above the actual point of safety. (The term "milk" shall be construed to include the fluid derivatives of milk wherever such construction of the term is applicable.)

### Licenses

#### requirements

No person shall engage in the sale, handling, or distribution of milk in ——— until he has obtained a license therefor from the health authorities. This license shall be renewed on or before the 1st day of ——— of each year and may be suspended or revoked at any time for cause.

#### recommendations

The application for the license shall include the following statements:

(1) Kind of milk to be handled or sold.

(2) Names of producers with their addresses and permit numbers.

(3) Names of middlemen with their addresses.

(4) Names and addresses of all stores, hotels, factories, and restaurants at which milk is delivered.

(5) A statement of the approximate number of quarts of milk, cream, buttermilk, and skim milk sold per day.

(6) Source of water supply at farms and bottling plants.

(7) Permission to inspect all local and out-of-town premises on which milk is produced and handled.

(8) Agreement to abide by all the provisions of State and local regulations.

### Permits

#### requirements

No person shall engage in the production of milk for sale in ———, nor shall any person engage in the handling of milk for shipment into ——— until he has obtained a permit therefor from the health authorities. This permit shall be renewed on or before the 1st day of ——— of each year and may be suspended or revoked at any time for cause.

## Production of Raw Milk

### Cow Stables

#### REQUIREMENTS

1. They shall be used for no other purpose than for the keeping of cows, and shall be light, well ventilated, and clean.
2. They shall be ceiled overhead if there is a loft above.
3. The floors shall be tight and sound.
4. The gutters shall be water-tight.

#### RECOMMENDATIONS

1. The window area shall be at least 2 sq. ft. per 500 cu. ft. of air space and shall be uniformly distributed, if possible. If uniform distribution is impossible, sufficient additional window area must be provided so that all portions of the barn shall be adequately lighted.
2. The amount of air space shall be at least 500 cu. ft. per cow, and adequate ventilation besides windows shall be provided.
3. The walls and ceilings shall be whitewashed at least once every 6 months, unless the construction renders it unnecessary, and shall be kept free from cobwebs and dirt.
4. All manure shall be removed at least twice daily, and disposed of so as not to be a source of danger to the milk either as furnishing a breeding place for flies or otherwise.
5. Horse manure shall not be used in the cow stable for any purpose.

#### REQUIREMENTS

Every milk farm shall be provided with a milk room that is clean, light, and well screened. It shall be used for no other purpose than for the cooling, bottling, and storage of milk and the operations incident thereto.

#### RECOMMENDATIONS

1. It shall have no direct connection with any stable or dwelling.
2. The floors shall be of cement or other impervious material, properly graded and drained.
3. It shall be provided with a sterilizer unless the milk is sent to a bottling plant, in which case the cans shall be sterilized at the plant.
4. Cooling and storage tanks shall be drained and cleaned at least twice each week.
5. All drains shall discharge at least 100 ft. from any milk house or cow stable.

### Cows

#### REQUIREMENTS

1. A physical examination of all cows shall be made at least once every six months by a veterinarian approved by the health authorities.
2. Every diseased cow shall be removed from the herd at once and no milk from such cows shall be offered for sale.
3. The tuberculin test shall be applied at least once a year by a veterinarian approved by the health authorities.

4. All cows which react shall be removed from the herd at once, and no milk from such cows shall be sold as raw milk.

5. No new cows shall be added to a herd until they have passed a physical examination and the tuberculin test.

6. Cows, especially the udders, shall be clean at the time of milking.

7. No milk that is obtained from a cow within 15 days before or 5 days after parturition, nor any milk that has an unnatural odor or appearance, shall be sold.

8. No unwholesome food shall be used.

#### RECOMMENDATIONS

1. Every producer shall allow a veterinarian employed by the health authorities to examine his herd at any time under the penalty of having his supply excluded.

2. Certificates showing the results of all examinations shall be filed with the health authorities within 10 days of such examinations.

3. The tuberculin tests shall be applied at least once every 6 months by a veterinarian approved by the health authorities, unless on the last previous test no tuberculosis was present in the herd or in the herds from which new cows were obtained, in which event the test may be postponed an additional 6 months.

4. Charts showing the results of all tuberculin tests shall be filed with the health authorities within 10 days of the date of such test.

5. The udders shall be washed and wiped before milking.

### Employees

#### REQUIREMENTS

1. All employees connected in any way with the production and handling of milk shall be personally clean and shall wear clean outer garments.

3. The health authorities shall be notified at once of any communicable disease in any person that is in any way connected with the production or handling of milk, or of the exposure of such person to any communicable disease.

3. Milking shall be done only with dry hands.

#### RECOMMENDATIONS

1. Clean suits shall be put on immediately before milking.

2. The hands shall be washed immediately before milking each cow, in order to avoid conveyance of infection to the milk.

### Utensils

#### REQUIREMENTS

1. All utensils and apparatus with which milk comes in contact shall be thoroughly washed and sterilized, and no milk utensil or apparatus shall be used for any other purpose than that for which it was designed.

2. The owner's name, license number, or other identification mark, the nature of which shall be made known to the health authorities, shall appear in a conspicuous place on every milk container.

3. No bottle or can shall be removed from a house in which there is, or in which there has recently been, a case of communicable disease until permission in writing has been granted by the health authorities.

4. All metal containers and piping shall be in good condition at all times. All piping shall be sanitary milk piping, in couples short enough to be taken apart and cleaned with a brush.

5. Small-top milking pails shall be used.

#### RECOMMENDATIONS

1. All cans and bottles shall be cleaned as soon as possible after being emptied.

2. Every conveyance used for the transportation or delivery of milk, public carriers excepted, shall bear the owner's name, milk-license number, and business address in uncondensed gothic characters at least 2 in. in height.

### Handling of Milk

#### REQUIREMENTS

1. It shall not be strained in the cow stable, but shall be removed to the milk room as soon as it is drawn from the cow.

2. It shall be cooled to 50°F. or below within two hours after it is drawn from the cow and it shall be kept cold until it is delivered to the consumer.

3. It shall not be adulterated by the addition or the subtraction of any substance or compound, except for the production of the fluid derivatives allowed by law.

4. It shall not be tested by taste at any bottling plant, milk house, or other place in any way that may render it liable to contamination.

5. It shall be bottled only in a milk room or bottling plant for which a license or permit has been issued.

6. It shall be delivered in bottles, or single service containers, with the exception that 20 qt. or more may be delivered in bulk in the following cases:

(*a*) To establishments in which milk is to be consumed or used on the premises.

(*b*) To infant-feeding stations that are under competent medical supervision.

7. It shall not be stored in or sold from a living room or from any other place which might render it liable to contamination.

#### RECOMMENDATIONS

1. It shall be cooled to 50°F. or below immediately after milking and shall be kept at or below that temperature until it is delivered to the consumer.

2. It shall contain no visible foreign material.

3. It shall be labeled with the date of production.

### Receiving Stations and Bottling Plants

#### REQUIREMENTS

1. They shall be clean, well screened, and lighted, and shall be used for no other purpose than the proper handling of milk and the operations incident thereto, and shall be open to inspection by the health authorities at any time.

2. They shall have smooth, impervious floors, properly graded and drained.

3. They shall be equipped with hot and cold water and steam.

4. Ample provision shall be made for steam sterilization of all utensils, and no empty milk containers shall be sent out until after such sterilization.

5. All utensils, piping, and tanks shall be kept clean and shall be sterilized daily.

#### RECOMMENDATIONS

1. Containers and utensils shall not be washed in the same room in which milk is handled.

### Stores

#### REQUIREMENTS

1. All stores in which milk is handled shall be provided with a suitable room or compartment in which the milk shall be kept. Said compartment shall be clean and shall be so arranged that the milk will not be liable to contamination of any kind.
2. Milk shall be kept at a temperature not exceeding 50°F.

#### RECOMMENDATIONS

1. Milk to be consumed off the premises may be sold from stores only in the original unopened package.

### General Regulations

#### REQUIREMENTS

1. The United States Bureau of Animal Industry score card shall be used, and it is recommended that dairies from which milk is to be sold in a raw state shall score at least 80 points.
2. Every place where milk is produced or handled and every conveyance used for the transportation of milk shall be clean.
3. All water supplies shall be from uncontaminated sources and from sources not liable to become contaminated.
4. The license or permit shall be kept posted in a conspicuous place in every establishment for the operation of which a milk license or permit is required.
5. No milk license or permit shall at any time be used by any person other than the one to whom it was granted.
6. No place for the operation of which a license or permit is granted shall be located within 100 ft. of a privy or other possible source of contamination, nor shall it contain or open into a room which contains a water-closet.
7. No skim-milk or buttermilk shall be stored in or sold from cans or other containers unless such containers are of a distinctive color and permanently and conspicuously labeled "skim-milk" or "buttermilk," as the case may be.
8. No container shall be used for any other purpose than that for which it is labeled.

#### RECOMMENDATIONS

1. Ice used for cooling purposes shall be clean and uncontaminated.
2. No person whose presence is not required shall be permitted to remain in any cow stable, milk house, or bottling room.

## Subnormal Milk

### REQUIREMENTS

1. Natural milk that contains less than 3.25 per cent., but more than 2.5 per cent. milk fat, and that complies in all other respects with the requirements above set forth, may be sold, provided the percentage of fat does not fall below a definite percentage that is stated in a conspicuous manner on the container; and further provided that such container is conspicuously marked "substandard milk."

## Production of Cream

### REQUIREMENTS AND RECOMMENDATIONS

1. It shall be obtained from milk that is produced and handled in accordance with the provisions hereinbefore set forth for the production and handling of milk.

## Standards for Milk

### REQUIREMENTS

1. It shall not contain more than 100,000 bacteria per cubic centimeter.
2. It shall contain not less than 3.25 per cent. milk fat.
3. It shall contain not less than 8.5 per cent. solids-not-fat.

### RECOMMENDATIONS

1. The bacterial limit shall be lowered if possible.

## Standards for Cream

### REQUIREMENTS

1. There shall be a bacterial standard for cream corresponding to the grade of milk from which it is made and to its butterfat content.
2. It shall contain not less than 18 per cent. milk fat.

### RECOMMENDATIONS

Same as above for milk.

## Standards for Skim-milk

### REQUIREMENTS

1. It shall contain not less than 8.75 per cent. milk solids.
2. Control of sale of skim-milk: Whether skim-milk is sold in wagons or in stores all containers holding skim-milk should be painted some bright, distinctive color and prominently and legibly marked "skim-milk." When skim-milk is placed in the buyer's container, a label or tag bearing the words "skim-milk" should be attached.

## Production of Pasteurized Milk

Pasteurized milk is milk that is heated to a temperature of not less than 140°F. for not less than 20 min., or not over 155°F. for not less than 5 min., and for

each degree of temperature over 140°F. the length of time may be 1 min. less than 20. Said milk shall be cooled immediately to 50°F. or below and kept at or below that temperature.

### Cow Stables

#### REQUIREMENTS

The same as for the production of raw milk.

#### RECOMMENDATIONS

The same as for the production of raw milk.

### Milk Room

#### REQUIREMENTS

The same as for the production of raw milk.

#### RECOMMENDATIONS

The same as for the production of raw milk.

### Cows

#### REQUIREMENTS

The same as for the production of raw milk, with the exception of the sections relating to the tuberculin test.

#### RECOMMENDATIONS

That no cows be added to a herd excepting those found to be free from tuberculosis by the tuberculin test.

### Employees

#### REQUIREMENTS

The same as for the production of raw milk.

#### RECOMMENDATIONS

The same as for the production of raw milk.

### Utensils

#### REQUIREMENTS

The same as for the production of raw milk.

#### RECOMMENDATIONS

The same as for the production of raw milk.

### Milk for Pasteurization

#### REQUIREMENTS

1. The same as for the production of raw milk, with the exception of sections 1, 2, and 6*b*.

2. It shall be cooled to 60°F. or below within two hours after it is drawn from the cow, and it shall be held at or below that temperature until it is pasteurized. After pasteurization, it shall be held at a temperature not exceeding 50°F. until delivered to the consumer.

3. Pasteurized milk shall be distinctly labeled as such, together with the temperature at which it is pasteurized and the shortest length of exposure to that temperature and the date of pasteurization.

#### RECOMMENDATIONS

1. No milk shall be repasteurized.
2. The requirements governing the production and handling of milk for pasteurization should be raised wherever practicable.

### Pasteurizing Plants

#### REQUIREMENTS

The same as under "Receiving stations and bottling plants" for raw milk.

#### RECOMMENDATIONS

The same as under "Receiving stations and bottling plants" for raw milk.

### Stores

#### REQUIREMENTS

The same as for raw milk.

#### RECOMMENDATIONS

The same as for raw milk.

### General Regulations

#### REQUIREMENTS

1. It is recommended that dairies producing milk which is to be pasteurized shall be scored on the United States Bureau of Animal Industry score card, and that health departments, or the controlling departments whatever they may be, strive to bring these scores up as rapidly as possible.
2. Milk from cows that have been rejected by the tuberculin test, but which show no physical signs of tuberculosis, as well as those which have not been tested, may be sold provided that it is produced and handled in accordance with all the other requirements herein set forth for pasteurized milk.
3. Ice used for cooling purposes shall be clean.

#### RECOMMENDATIONS

The same as for raw milk.

### Production of Pasteurized Cream

#### REQUIREMENTS

1. It shall be obtained only from milk that could legally be sold as milk under the requirements hereinbefore set forth.

2. Pasteurized cream, or cream separated from pasteurized milk, shall be labeled in the manner herein provided for the labeling of pasteurized milk.

### Standards for Pasteurized Milk

#### REQUIREMENTS

1. It shall not contain more than 1,000,000 bacteria per cubic centimeter before pasteurization, nor over 50,000 when delivered to the consumer.

2. The standards for the percentage of milk fat and of total solids shall be the same as for raw milk.

#### RECOMMENDATIONS

1. The limits for the bacterial count before pasteurization and after pasteurization should both be lowered if possible.

### Standards for Pasteurized Cream

#### REQUIREMENTS

1. No cream shall be sold that is obtained from pasteurized milk that could not be legally sold under the provisions herein set forth, nor shall any cream that is pasteurized after separation contain an excessive number of bacteria.

2. There shall be a bacterial standard for pasteurized cream corresponding to the grade of milk from which it is made and to its butterfat content.

3. The percentage of milk fat shall be the same as for raw cream.

**Production of Certified Milk.**—The production of certified milk is conducted in a way that is intended to assure a product of exceptional cleanliness and purity for the use of infants and invalids. Ernest Kelly in *Bulletin* 1 of the U. S. Department of Agriculture has taken up "Medical Milk Commissions and Certified Milk" and the brief account of the work of certified dairies that follows is principally drawn from his bulletin. Certified milk is the result of the effort of the Medical Society of New Jersey to improve the milk supply of that State. In 1889 the Society appointed a committee to investigate the public health aspect of dairying in New Jersey with the outcome that after 2 years' work the committee made a report which was the basis of an appeal to the State to undertake the supervision of the dairies within its limits. The desirability of doing so was admitted by the authorities but the appeal was denied on the ground of lack of funds.

Then in 1892 Dr. Henry L. Coit, the chairman of the Committee presented a plan to the Practitioner's Club of Newark whereby the physicians themselves could control the production of milk. It was recommened that the physicians should form a commission that should certify the milk produced in accordance with their requirements. The Club accepted the report and on April 13, 1893, organized the first milk commission. It was composed of physicians of Newark, Orange and Montclair and adopted the name of "The Medical Milk Commission of Essex County, New Jersey." A contract was made with Stephen Francisco, proprietor

of the Fairfield Dairy of Montclair for the production of the milk. The term "certified milk" proposed by Dr. Coit, was adopted and later, on Oct. 18, 1904, at the instance of Mr. Francisco the word "certified" was registered in the U. S. Patent office under registry number 25,368 to protect the word from being used by dairymen not working under a medical milk commission but with the understanding that it might be employed without question by all such commissions. So, certified milk is properly only that milk which is produced under the direction of a Medical Milk Commission, usually appointed by the County or State Medical Society. In New Jersey, New York, and some other States only milk that is so produced can legally be sold as certified milk but elsewhere dealers may impose on the public by selling a milk which they certify themselves, or get someone else to, as certified milk.

This first commission was successful and was soon overwhelmed by correspondence from all parts of the United States, relative to the mode of establishing and conducting the certified milk business and other early commissions were burdened in the same way. This led to Dr. Otto P. Geier of Cincinnati proposing a conference of the commissions which was held at the meeting of the American Medical Association at Atlantic City, N. J., on June 3, 1907. A permanent organization under the name of the American Association of Medical Milk Commission was effected with Dr. Coit as President and Dr. Geier as Secretary. Annual conferences have been held since that time and to date the instructive proceedings of eight conferences have been issued by the Association. This first conference marked an important forward step in bettering the milk supplies of the country for committees were appointed to investigate many different phases of dairying and so the forces that were working for better milk became organized and found national expression.

The influence of these medical milk commissions has been very great. In the first place they have furnished clean pure milk to physicians for the use of children and invalids and in the second they have demonstrated that it was possible to produce and market a milk of superior flavor and keeping qualities. In the third, their direct and indirect influence on other dairies has been very important for some commissions have inspected other dairies in their vicinity that were not producing certified milk and enabled the satisfactory ones, with their approval, to market milk under an "inspected" label and the equipment and methods of their certified dairies have served as models for other dairymen. Finally, they arouse public interest in pure milk for physicians practising in their vicinity are alive to its importance and the people by contact with these men and often by literature furnished by the commissions learn the value of pure milk and make some effort to secure it for their families.

It should be understood that certified milk has no unusual properties other than those of exceptional cleanliness and purity. It is the process

of production of the milk that is certified to and not either the exact composition of the milk or its absolute freedom from morbific principles. Certified milk is produced from all sorts of cattle from natives to grades to purebreds of the five principal dairy breeds so that the composition of the milk must inevitably vary. By insisting on veterinary inspection of the herds, on their being kept in proper surroundings, on their being fed wholesome rations and tended by healthy employees and by seeing to it that the milk is properly handled and transported the commissions offer to the public a raw milk that is very unlikely to be unwholesome or infected, nevertheless it is impossible to guarantee that some cow with an undetected udder ailment or some bacillus carrier or mildly sick person has not infected it. The fact that certified dairies have very seldom been connected in any way with outbreaks of communicable disease shows that the danger of the milk being infected is very slight; still there are some who would pasteurize certified milk.

The high quality of milk that may be produced by certified dairies has recently been shown by Kelly, who has given out the results of the scoring of milk by the U. S. Department of Agriculture in cream contests wherein both certified and market milks have been entered. These scores are given in Table 116.

TABLE 116.—AVERAGE SCORES OF CERTIFIED AND MARKET MILK IN MILK AND CREAM CONTESTS (KELLY)

| | Possible score | Certified | Market | Possible score | Certified | Market |
|---|---|---|---|---|---|---|
| Bacteria | 35.00 | 30.45 | 23.87 | 35.00 | 29.37 | 21.32 |
| Flavor and odor | 25.00 | 19.50 | 20.05 | 25.00 | 20.11 | 19.26 |
| Visible dirt | 10.00 | 8.85 | 8.36 | 10.00 | 9.37 | 8.77 |
| Fat | 10.00 | 9.64 | 9.13 | 20.00 | 19.53 | 19.75 |
| Solids-not-fat | 10.00 | 9.84 | 9.47 | ........ | ........ | ........ |
| Acidity | 5.00 | 4.73 | 4.62 | 5.00 | 4.74 | 4.70 |
| Bottle and top | 5.00 | 4.95 | 4.53 | 5.00 | 4.80 | 4.62 |
| Total | 100.00 | 87.96 | 80.05 | 100.00 | 87.82 | 78.42 |

These scores presumably represent the products at their best. It appears that on the bacterial count the certified milk scored nearly 7 points higher than the market milk, and led it in all other respects except in flavor in which it fell behind half a point. Certified cream scored 8 points higher than market cream and was superior to it in every other way except fat content in which it was less than 1 point behind.

It is required that all certified milk shall reach the consumer within 30 hr. after milking but it easily keeps sweet much longer than that. Occasionally it is put aboard ocean liners by travelers to Europe who have it kept cold and use it throughout the voyage. At the Paris exposition in 1900 certified milk from the United States, to the astonishment of the

judges, was placed on exhibition in perfectly sweet condition after a journey of 14 to 18 days over 3,000 to 4,000 miles in midsummer. One producer told this writer that some of his milk was sweet and was drunk with relish in Labrador 7 weeks after it was produced. At the National Dairy Shows and various expositions certified milk from all parts of the United States and Canada is put on exhibition with a low bacterial count.

*Courtesy of Stephen Francisco.*

Fig. 60.—Producing certified milk in the shed barn of the Fairfield Dairy at Caldwell, N. J. Several barn operations such as washing and drying the cows udders and the use of a vacuum cleaner for cleaning the cows, are shown.

It is of course inadvisable to drink old milk because it may support a growth of noxious germs that are indetectable by taste.

Certified milk is produced in buildings of approved construction many of which are very expensive but enough has been produced in moderate-priced structures to show that a costly plant is unnecessary. Thorough sanitation is maintained; the 37 certified farms scored by the U. S. Department of Agriculture had an average score of about 90 and that the lowest score on record in the department of any certified dairy is 73.6.

The cows from which certified milk is produced are tuberculin-tested; the bedding is usually of sawdust, or shavings; the cows are generally

fed after milking; pastures and barnyards are well-drained; particular attention is paid to the utensils; small-top pails are almost always used; the cows are carefully groomed long enough before milking to let the dust settle; milkers scrub up thoroughly before starting to milk and wear clean suits consisting of overalls, jumpers and caps; as each cow is milked her milk is brought to the milk room where it is strained; under the best management the milkers wash their hands before milking the next cow. The milk is cooled either before or after bottling. The bottle caps are of a style that completely cover the top of the bottle and many dairies use a double cap. The caps are sterilized by dry heat before being used. In transit the milk is kept cold. Some certified dairies deliver their own milk while others distribute it through a city milk dealer.

Kelly states that in a study of 92 certified dairies in 17 States he found that the number of cows to a herd varied from 9 to 600 and that the average was 88. The amount of milk handled ranged from 12.5 to 6,000 qt. and averaged 747.5 qt. The average production per cow per day was 8.3 qt. which was above that of the cows in market dairies but which he regards as lower than it should be. The bacterial count of certified dairies varies up to 30,000 per cubic centimeter, probably most of them expect to keep it below 10,000 per cubic centimeter. In this study one of the dairies reported that its plates ran from sterile to 1,000 per cubic centimeter, and three reported counts of 20,000 per cubic centimeter, but the average of all was 4,069 per cubic centimeter. It was stated that a few of the producers put their milk on the market when it was 6 hr. most when it was 20 hr. and a few others when it was 48 hr. old.

Kelly estimates that in 1912 the total production of certified milk per day was 25,000 gal. which was a 300 per cent. increase since 1907. Among 43 active commissions that replied to his queries the most milk, certified per day by a single one, was 10,752 qt.

It is probable that in none of our large cities does the production of certified milk greatly exceed 1 per cent. of the total supply. The reason for this is the high price asked for certified milk. It nearly always costs more than most milk users can afford to pay. So certified milk solves the milk question only for the wealthy. Undoubtedly it is expensive to produce certified milk but it seems certain that in the past certified dairies in general have not been managed in the most economical and efficient way possible. This has had a bad effect in two ways: it has limited the field of activity of medical milk commissions and it has tended to discourage dairymen from making the effort to adopt sanitary measures and produce a high grade of market milk. It is desirable that the business side of dairying be more strongly emphasized by the commissions in the future.

In doing this it would seem that expensive building and unnecessary apparatus should be tabooed and that an effort should be made to cheapen

production by attempting to control only those sources of bacterial contamination that the most recent studies of barn contamination have shown to be important. Such doctrine may be heretical but it seems to the writer that more good would be accomplished by the producers of certified milk, if instead of striving to market milk with bacterial counts of less than 10,000 per cubic centimeter, which few can afford to buy, they would be content to keep the counts between 25,000 and 50,000 per cubic centimeter and so, produce milk at less cost, that might be sold at a price within the means of a larger public.

The members of milk commissions usually give their services gratis and they even pay for the minor expenses of carrying on the work themselves. Some money for expenses is derived from a charge that is made for certification. This may be at so much per year for each dairy, at so much per 1,000 caps or at so much per quart of milk produced. The salaries of the experts in the service of the commission are commonly paid by the dairyman.

The immediate control of the production of certified milk is in the hands of the medical milk commissions which certify it. The American Association of Medical Milk Commissions in 1912 promulgated the following rules for the production of certified milk.

## Hygiene of the Dairy

### UNDER THE SUPERVISION AND CONTROL OF THE VETERINARIAN

1. *Pastures or Paddocks.*—Pastures or paddocks to which the cows have access shall be free from marshes or stagnant pools, crossed by no stream which might become dangerously contaminated, at sufficient distances from offensive conditions to suffer no bad effects from them, and shall be free from plants which affect the milk deleteriously.

2. *Surroundings of Buildings.*—The surroundings of all buildings shall be kept clean and free from accumulations of dirt, rubbish, decayed vegetable or animal matter or animal waste, and the stable yard shall be well drained.

3. *Location of Buildings.*—Buildings in which certified milk is produced and handled shall be so located as to insure proper shelter and good drainage, and at sufficient distance from other buildings, dusty roads, cultivated and dusty fields, and all other possible sources of contamination; provided, in the case of unavoidable proximity to dusty roads or fields, the exposed side shall be screened with cheese cloth.

4. *Construction of Stables.*—The stables shall be constructed so as to facilitate the prompt and easy removal of waste products. The floors and platforms shall be made of cement or other non-absorbent material, and the gutters of cement only. The floors shall be properly graded and drained, and the manure gutters shall be from 6 to 8 in. deep and so placed in relation to the platform that all manure will drop into them.

5. The inside surface of the walls and all interior construction shall be smooth, with tight joints, and shall be capable of shedding water. The ceiling shall be

of smooth material and dust-tight. All horizontal and slanting surfaces which might harbor dust shall be avoided.

6. *Drinking and Feed Troughs.*—Drinking troughs or basins shall be drained and cleaned each day, and feed troughs and mixing floors shall be kept in a clean and sanitary condition.

7. *Stanchions.*—Stanchions when used shall be constructed of iron pipes or hardwood, and throat latches shall be provided to prevent the cows from lying down between the time of cleaning and the time of milking.

8. *Ventilation.*—The cow stables shall be provided with adequate ventilation either by means of some approved artificial device, or by the substitution of cheese cloth for glass in the windows, each cow to be provided with a minimum of 600 cu. ft. of air space.

9. *Windows.*—A sufficient number of windows shall be installed and so distributed as to provide satisfactory light and a maximum of sunshine; 2 ft. square of window area to each 600 cu. ft. of air space to represent the minimum. The coverings of such windows shall be kept free from dust and dirt.

10. *Exclusion of Flies, Etc.*—All necessary measures should be taken to prevent the entrance of flies and other insects, and rats and other vermin into all the buildings.

11. *Exclusion of Animals from the Herd.*—No horses, hogs, dogs, or other animals or fowls shall be allowed to come in contact with the certified herd either in the stables or elsewhere.

12. *Bedding.*—No dusty or mouldy hay or straw, bedding from horse stalls, or other unclean materials shall be used for bedding the cows. Only bedding which is clean, dry, and absorbent may be used, preferably shavings or straw.

13. *Cleaning Stable and Disposal of Manure.*—Soiled bedding and manure shall be removed at least twice daily, and the floors shall be swept and kept free from refuse. Such cleaning shall be done at least 1 hr. before the milking time. Manure, when removed, shall be drawn to the field or temporarily stored in containers so screened as to exclude flies. Manure shall not be even temporarily stored within 300 ft. of the barn or dairy building.

14. *Cleaning of Cows.*—Each cow in the herd shall be groomed daily, and no manure, mud, or filth shall be allowed to remain upon her during milking; for cleaning, a vacuum apparatus is recommended.

15. *Clipping.*—Long hairs shall be clipped from the udder and flanks of the cow, and from the tail above the brush. The hair on the tail shall be cut so that the brush may be well above the ground.

16. *Cleaning of Udders.*—The udders and teats of the cow shall be cleaned before milking; they shall be washed with a cloth and water, and dry wiped with another clean sterilized cloth—a separate cloth for drying each cow.

17. *Feeding.*—All foodstuffs shall be kept in an apartment separate from and not directly communicating with the cow barn. They shall be brought into the barn only immediately before the feeding hour, which shall follow the milking.

18. Only those foods shall be used which consist of fresh, palatable, or nutritious materials, such as will not injure the health of the cows or unfavorably affect the taste or character of the milk. Any dirty or mouldy food or food in a state of decomposition or putrefaction shall not be given.

19. A well-balanced ration shall be used, and all changes of food shall be made

slowly. The first few feedings of grass, alfalfa, ensilage, green corn, or other green feeds shall be given in small rations and increased gradually to full ration.

20. *Exercise.*—All dairy cows shall be turned out for exercise at least 2 hr. in each 24 in suitable weather. Exercise yards shall be kept free from manure and other filth.

21. *Washing of Hands.*—Conveniently located facilities shall be provided for the milkers to wash in before and during milking.

22. The hands of the milkers shall be thoroughly washed with soap, water, and brush and carefully dried on a clean towel immediately before milking. The hands of the milkers shall be rinsed with clean water and carefully dried before milking each cow. The practice of moistening the hands with milk is forbidden.

23. *Milking Clothes.*—Clean overalls, jumper, and cap shall be worn during milking. They shall be washed or sterilized each day and used for no other purpose, and when not in use they shall be kept in a clean place, protected from dust and dirt.

24. *Things to be Avoided by Milkers.*—While engaged about the dairy or in handling the milk employees shall not use tobacco nor intoxicating liquors. They shall keep their fingers away from their nose and mouth, and no milker shall permit his hands, fingers, lips, or tongue to come in contact with milk intended for sale.

25. During milking the milkers shall be careful not to touch anything but the clean top of the milking stool, the milk pail, and the cow's teats.

26. Milkers are forbidden to spit upon the walls or floors of stables, or upon the walls or floors of milk houses, or into the water used for cooling the milk or washing the utensils.

27. *Fore-milk.*—The first streams from each teat shall be rejected, as this fore milk contains large numbers of bacteria. Such milk shall be collected into a separate vessel and not milked onto the floors or into the gutters. The milking shall be done rapidly and quietly, and the cows shall be treated kindly.

28. *Milk and Calving Period.*—Milk from all cows shall be excluded for a period of 45 days before and 7 days after parturition.

29. *Bloody and Stringy Milk.*—If milk from any cow is bloody and stringy or of unnatural appearance, the milk from that cow shall be rejected and the cow isolated from the herd until the cause of such abnormal appearance has been determined and removed, special attention being given in the meantime to the feeding or to possible injuries. If dirt gets into the pail, the milk shall be discarded and the pail washed before it is used.

30. *Make-up of Herd.*—No cows except those receiving the same supervision and care as the certified herd shall be kept in the same barn or brought in contact with them.

31. *Employees Other than Milkers.*—The requirements for milkers, relative to garments and cleaning of hands, shall apply to all other persons handling the milk, and children unattended by adults shall not be allowed in the dairy nor in the stable during milking.

32. *Straining and Strainers.*—Promptly after the milk is drawn it shall be removed from the stable to a clean room and then emptied from the milk pail to the can, being strained through strainers made of a double layer of finely meshed cheese cloth or absorbent cotton thoroughly sterilized. Several strainers

shall be provided for each milking in order that they may be frequently changed.

33. *Dairy Building.*—A dairy building shall be provided which shall be located at a distance from the stable and dwelling prescribed by the local commission, and there shall be no hogpen, privy, or manure pile at a higher level or within 300 ft. of it.

34. The dairy building shall be kept clean and shall not be used for purposes other than the handling and storing of milk and milk utensils. It shall be provided with light and ventilation, and the floors shall be graded and water-tight.

35. The dairy building shall be well lighted and screened and drained through well-trapped pipes. No animals shall be allowed therein. No part of the dairy building shall be used for dwelling or lodging purposes, and the bottling room shall be used for no other purpose than to provide a place for clean milk utensils and for handling the milk. During bottling this room shall be entered only by persons employed therein. The bottling room shall be kept scrupulously clean and free from odors.

36. *Temperature of Milk.*—Proper cooling to reduce the temperature to 45°F. shall be used, and aerators shall be so situated that they can be protected from flies, dust, and odors. The milk shall be cooled immediately after being milked, and maintained at a temperature between 35° and 45°F. until delivered to the consumer.

37. *Sealing of Bottles.*—Milk, after being cooled and bottled, shall be immediately sealed in a manner satisfactory to the commission, but such seal shall include a sterile hood which completely covers the lip of the bottle.

38. *Cleaning and Sterilizing of Bottles.*—The dairy building shall be provided with approved apparatus for the cleansing and sterilizing of all bottles and utensils used in milk production. All bottles and utensils shall be thoroughly cleaned by hot water and sal soda, or equally pure agent, rinsed until the cleaning water is thoroughly removed, then exposed to live steam or boiling water at least 20 min., and then kept inverted until used, in a place free from dust and other contaminating materials.

39. *Utensils.*—All utensils shall be so constructed as to be easily cleaned. The milk pail should preferably have an elliptical opening 5 by 7 in. in diameter. The cover of this pail should be so convex as to make the entire interior of the pail visible and accessible for cleaning. The pail shall be made of heavy seamless tin, and with seams which are flushed and made smooth by solder. Wooden pails, galvanized-iron pails, or pails made of rough, porous materials, are forbidden. All utensils used in milking shall be kept in good repair.

40. *Water Supply.*—The entire water supply shall be absolutely free from contamination, and shall be sufficient for all dairy purposes. It shall be protected against flood or surface drainage, and shall be conveniently situated in relation to the milk house.

41. *Privies, etc., in Relation to Water Supply.*—Privies, pigpens, manure piles, and all other possible sources of contamination shall be so situated on the farm as to render impossible the contamination of the water supply, and shall be so protected by use of screens and other measures as to prevent their becoming breeding grounds for flies.

42. *Toilet Rooms.*—Toilet facilities for the milkers shall be provided and

located outside of the stable or milk house. These toilets shall be properly screened, shall be kept clean, and shall be accessible to wash basins, water, nail brush, soap and towels, and the milkers shall be required to wash and dry their hands immediately after leaving the toilet room.

### Transportation

43. In transit the milk packages shall be kept free from dust and dirt. The wagon, trays, and crates shall be kept scrupulously clean. No bottles shall be collected from houses in which communicable diseases prevail, unless a separate wagon is used and under conditions prescribed by the department of health and the medical milk commission.

44. All certified milk shall reach the consumer within 30 hr. after milking.

### Veterinary Supervision of the Herd

45. *Tuberculin Test.*—The herd shall be free from tuberculosis, as shown by the proper application of the tuberculin test. The test shall be applied in accordance with the rules and regulations of the United States Government, and all reactors shall be removed immediately from the farm.[1]

46. No new animals shall be admitted to the herd without first having passed a satisfactory tuberculin test, made in accordance with the rules and regulations mentioned; the tuberculin to be obtained and applied only by the official veterinarian of the commission.

47. Immediately following the application of the tuberculin test to a herd for the purpose of eliminating tuberculous cattle, the cow stable and exercising yards shall be disinfected by the veterinary inspector in accordance with the rules and regulations of the United States Government.[1]

48. A second tuberculin test shall follow each primary test after an interval of 6 months, and shall be applied in accordance with the rules and regulations mentioned. Thereafter, tuberculin tests shall be reapplied annually, but it is recommended that the retests be applied semiannually.

49. *Identification of Cows.*—Each dairy cow in each of the certified herds shall be labeled or tagged with a number or mark which will permanently identify her.

50. *Herd-book Record.*—Each cow in the herd shall be registered in a herd book which register shall be accurately kept so that her entrance and departure from the herd and her tuberculin testing can be identified.

51. A copy of this herd-book record shall be kept in the hands of the veterinarian of the medical milk commission under which the dairy farm is operating, and the veterinarian shall be made responsible for the accuracy of this record.

52. *Dates of Tuberculin Tests.*—The dates of the annual tuberculin tests shall be definitely arranged by the medical milk commission, and all of the results of such tests shall be recorded by the veterinarian and regularly reported to the secretary of the medical milk commission issuing the certificate.

53. The results of all tuberculin tests shall be kept on file by each medical milk commission, and a copy of all such tests shall be made available to the American Association of Medical Milk Commissions for statistical purposes.

[1] See *Circular of Instructions* issued by the Bureau of Animal Industry for making tuberculin tests and for disinfection of premises.

54. The proper designated officers of the American Association of Medical Milk Commissions should receive copies of reports of all of the annual, semiannual, and other official tuberculin tests which are made and keep copies of the same on file and compile them annually for the use of the association.

55. *Disposition of Cows Sick with Diseases Other than Tuberculosis.*—Cows having rheumatism, leukorrhea, inflammation of the uterus, severe diarrhea, or disease of the udder, or cows that from any other cause may be a menace to the herd shall be removed from the herd, placed in a building separate from that which may be used for the isolation of cows with tuberculosis, unless such building has been properly disinfected since it was last used for this purpose. The milk from such cows shall not be used, nor shall the cows be restored to the herd until permission has been given by the veterinary inspector after a careful physical examination.

56. *Notification of Veterinary Inspector.*—In the event of the occurrence of any of the diseases just described between the visits of the veterinary inspector, or if at any time a number of cows become sick at one time in such a way as to suggest the outbreak of a contagious disease or poisoning, it shall be the duty of the dairyman to withdraw such sickened cattle from the herd, to destroy their milk, and to notify the veterinary inspector by telegraph or telephone immediately.

57. *Emaciated Cows.*—Cows that are emaciated from chronic diseases or from any cause that in the opinion of the veterinary inspector may endanger the qualty of the milk, shall be removed from the herd.

## Bacteriological Standards

58. *Bacterial Counts.*—Certified milk shall contain less than 10,000 bacteria per cubic centimeter when delivered. In case a count exceeding 10,000 bacteria per cubic centimeter is found, daily counts shall be made, and if normal counts are not restored within 10 days the certificate shall be suspended.

59. Bacterial counts shall be made at least once a week.

60. *Collection of Samples.*—The samples to be examined shall be obtained from milk as offered for sale and shall be taken by a representative of the milk commission. The samples shall be received in the original packages, in properly iced containers, and they shall be so kept until examined, so as to limit as far as possible changes in their bacterial content.

61. For the purpose of ascertaining the temperature, a separate original package shall be used, and the temperature taken at the time of collecting the sample, using for the purpose a standardized thermometer graduated in the centigrade scale.

62. *Interval between Milking and Plating.*—The examinations shall be made as soon after collection of the samples as possible, and in no case shall the interval between milking and plating the samples be longer than 40 hr.

63. *Plating.*—The packages shall be opened with aseptic precautions after the milk has been thoroughly mixed by vigorously reversing and shaking the container 25 times.

64. Two plates at least shall be made for each sample of milk, and there shall also be made a control of each lot of medium and apparatus used at each testing. The plates shall be grown at 37°C. for 48 hr.

65. In making the plates there shall be used agar agar media containing 1.5 per cent. agar and giving a reaction of 1.0 to phenolphthalein.

The following is the method recommended by a committee of the American Public Health Association for the making of the media, modified, however, as to the agar content and reaction to conform to the requirements specified in section 65 (see author's note at end of the methods):

1. Boil 15 grams of thread agar in 500 c.c. of water for half an hour and make up weight to 500 grams or digest for 10 min. in the autoclave at 110°C. Let this cool to about 60°C.
2. Infuse 500 grams finely chopped lean beef for 24 hr. with its own weight of distilled water in the refrigerator.
3. Make up any loss by evaporation.
4. Strain infusion through cotton flannel, using pressure.
5. Weigh filtered infusion.
6. Add Witte's peptone, 2 per cent.
7. Warm on water bath, stirring until peptone is dissolved and not allowing temperature to rise above 60°C.
8. To the 500 grams of meat infusion (with peptone) add 500 grams of the 2 per cent. agar, keeping the temperature below 60°C.
9. Heat over boiling water (or steam) bath 30 min.
10. Restore weight lost by evaporation.
11. Titrate after boiling 1 min. to expel carbonic acid.
12. Adjust reaction to final point desired +1 by adding normal sodium hydrate.
13. Boil 2 min. over free flame, constantly stirring.
14. Restore weight lost by evaporation.
15. Filter through absorbent cotton or coarse filter paper, passing the filtrate through the filter repeatedly until clear.
16. Titrate and record the final reaction.
17. Tube (10 c.c. to a tube) and sterilize in autoclave 1 hr. at 15 lb. pressure or in the streaming steam for 20 min. on three successive days.

66. Samples of milk for plating shall be diluted in the proportion of 1 part of milk to 99 parts of sterile water; shake 25 times and plate 1 c.c. of the dilution.

The committee on bacterial milk analyses of the American Public Health Association in Part IV of its report presented details with respect to plating apparatus and technique in part as follows:

*Plating Apparatus.*—For plating it is best to have a water bath in which to melt the media and a water-jacketed water bath for keeping it at the required temperature; a wire rack which should fit both the water baths for holding the media tubes; a thermometer for recording the temperature of the water in the water-jacketed bath, sterile 1-c.c. pipettes, sterile Petri dishes, and sterile dilution water in measured quantities.

*Dilutions.*—Ordinary potable water, sterilized, may be used for dilutions. Occasionally spore forms are found in such water which resist ordinary autoclave sterilization; in such cases distilled water may be used or the autoclave pressure increased. With dilution water in 8-oz. bottles calibrated for 99 c.c. * * * all the necessary dilutions may be made.

Short, wide-mouthed "blakes" or wide-mouthed French square bottles are more easily handled and more economical of space than other forms of bottles or flasks.

Eight-ounce bottles are the best, as the required amount of dilution water only about half fills them, leaving room for shaking. Long-fiber non-absorbent cotton should be used for plugs. It is well to use care in selecting cotton for this purpose

to avoid short-fiber or dusty cotton, which give a cloud of lint-like particles on shaking. Bottles * * * should be filled a little over the 99 c.c. * * * to allow for loss during sterilization.

*Pipettes.*—Straight sides 1-c.c. pipettes are more easily handled than those with bulbs; they may be made from ordinary 3⁄16-in. glass tubing and should be about 10 in. in length.

*Plating Technique.*—The agar after melting should be kept in the water-jacketed water bath between 40°C. and 45°C. for at least 15 min. before using to make sure that the agar itself has reached the temperature of the surrounding water. If used too warm, the heat may destroy some of the bacteria or retard their growth.

Shake the milk sample 25 times, then with a sterile pipette transfer 1 c.c. to the first dilution water and rinse the pipette by drawing dilution water to the mark and expelling; this gives a dilution 1 to 100.

* * * Then with a sterile pipette transfer 1 c.c. to the Petri dish, using care to raise the cover only as far as necessary to insert the end of the pipette.

Take the tube of agar from the water bath, wipe the water from outside the tube with a piece of cloth, remove the plug, pass the mouth of the tube through a flame, and pour the agar into the plate, using the same care as before to avoid exposure of the plate contents to the air.

Carefully and thoroughly mix the agar and diluted milk in the Petri dish by a rotary motion, avoiding the formation of air bubbles or slopping the agar, and after allowing the agar to harden for at least 15 min. at room temperature, place the dish bottom down in the incubator.

Plating should always be done in a place free from dust or currents of air.

In order that colonies may have sufficient food for proper development 10 c.c. of agar shall be used for each plate.

67. *Determination of Taste and Odor of Milk.*—After the plates have been prepared and placed in the incubator, the taste and odor of the milk shall be determined after warming the milk to 100°F.[1]

68. *Counts.*—The total number of colonies on each plate should be counted, and the results expressed in multiples of the dilution factor. Colonies too small to be seen with the naked eye or with slight magnification shall not be considered in the count.

69. *Records of Bacteriologic Tests.*—The results of all bacterial tests shall be kept on file by the secretary of each commission, copies of which should be made available annually for the use of the American Association of Medical Milk Commissions.

## Chemical Standards and Methods

The methods that must be followed in carrying out the chemical investigations essential to the protection of certified milk are so complicated that in order to keep the fees of the chemist at a reasonable figure, there must be eliminated from the examination those procedures which, whilst they might be helpful and interesting, are in no sense necessary.

For this reason the determination of the water, the total solids and the milk sugar is not required as a part of the routine examination.

[1] Should it be deemed desirable and necessary to conduct tests for sediment, the presence of special bacteria, or the number of leucocytes the methods adopted by the committee of the American Public Health Association should be followed.

70. The chemical analyses shall be made by a competent chemist designated by the medical milk commission.

71. *Method of Obtaining Samples.*—The samples to be examined by the chemist shall have been examined previously by the bacteriologist designated by the medical milk commission, as to temperature, odor, taste, and bacterial content.

72. *Fat Standards.*—The fat standard for certified milk shall be 4 per cent., with a permissible range of variation of from 3.5 to 4.5 per cent.

73. The fat standard for certified cream shall be not less than 18 per cent.

74. If it is desired to sell higher fat-percentage milks or creams as certified milks or creams, the range of variation for such milks shall be 0.5 per cent. on either side of the advertised percentage and the range of variations for such creams shall be 2 per cent. on either side of the advertised percentage.

75. The fat content of certified milks and creams shall be determined at least once each month.

76. The methods recommended for this purpose are the Babcock (*a*), the Leffmann-Beam (*b*), and the Gerber (*c*).

(*a*) *Babcock test.*—The Babcock test is based on the fact that strong sulphuric acid will dissolve the non-fatty solid constituents of milk, and thus enable the fat to separate on standing. It can be conducted by any of the Babcock outfits which are purchasable in the market.

"The test is made by placing in the special test bottle 18 grams (17.6 c.c.) of milk. To this is added, from a pipette, burette, or measuring bottle, 17.5 c.c. commercial sulphuric acid of a specific gravity of 1.82 to 1.83. The contents of the bottle are carefully and thoroughly mixed by a rotary motion. The mixture becomes brown and heat is generated. The test bottle is now placed in a properly balanced centrifuge and whirled for 5 min. at a speed of from 800 to 1,200 revolutions per min. Hot water is then added to fill the bottle to the lower part of the neck, after which it is again whirled for two minutes. Now, enough hot water is added to float the column of fat into the graduated portion of the neck of the bottle, and the whirling is repeated for a minute. The amount of fat is read while the neck of the bottle is still hot. The reading is from the upper limits of the meniscus. A pair of calipers is of assistance in measuring the column of fat." (Jensen's "Milk Hygiene," Leonard Pearson's translation.)

(*b*) *Leffman-Beam test.*—The distinctive feature is the use of fusel oil, the effect of which is to produce a greater difference in surface tension between the fat and the liquid in which it is suspended, and thus promote its readier separation. This effect has been found to be heightened by the presence of a small amount of hydrochloric acid.

The test bottles have a capacity of about 30 c.c. and are provided with a graduated neck, each division of which represents 9.1 per cent. by weight of butter fat.

Fifteen centimeters of the milk are measured into the bottle, 3 c.c. of a mixture of equal parts of amyl alcohol and strong hydrochloric acid added and mixed. Then 9 c.c. of concentrated sulphuric acid is added in portions of about 1 c.c.; after each addition the liquids are mixed by giving the bottle a gyratory motion. If the fluid has not lost all of its milky color by this treatment, a little more concentrated acid must be added. The neck of the bottle is now immediately filled at about the zero point with one part sulphuric acid and two parts water, well mixed just before using. Both the liquid in the bottle and the diluted acid must be hot. The bottle is then placed at once in the centrifugal machine; after rotation from one to two minutes, the fat will collect in the neck of the bottle and the percentage may be read off.

(*c*) *Gerber's test.*—This test is applied as follows: The test bottles are put into the

stand with the mouths uppermost; then, with the pipette designed for the purpose, or with an automatic measurer, 10 c.c. of sulphuric acid are filled into the test bottle, care being taken not to allow any to come in contact with the neck. The few drops remaining in the tip of the pipette should not be blown out. Then 11 c.c. of milk are measured with the proper pipette and allowed to flow slowly onto the acid, so that the two liquids mix as little as possible. Finally, the amyl alcohol is added. (It is important to use the reagents in the proper order, which is—sulphuric acid, milk, amyl alcohol. If the sulphuric acid is followed by amyl alcohol and the milk last, then the result is sometimes incorrect.) A rubber stopper, which must not be damaged, is then fitted into the mouth of the test bottle, and the contents are well shaken, the thumb being kept on the stopper to prevent it coming out. As a considerable amount of heat is generated by the action of the sulphuric acid on the milk. the test bottle should be wrapped in a cloth.

The shaking of the sample must be done thoroughly and quickly, and the test bottle inverted several times, so that the liquid in the neck becomes thoroughly mixed. By pressing in the rubber stopper the height of the liquid can be brought to about the zero point on the scale.

If only a few samples have to be analyzed and the room is warm, the test bottles can be put into the centrifuge without any preliminary heating, otherwise the test bottles must be warmed for a few minutes (not longer) in the water bath at a temperature of 60° to 65°C. When the temperature rises higher than this, say above 70°C., the rubber stopper is liable to be blown out of the test bottle. After the test bottles have been heated they are arranged symmetrically in the centrifuge and whirled for 3 to 4 min. at a speed of about 1,000 revolutions per min. When the centrifuge has a heating arrangement attached to it, the preliminary warming is not, of course, necessary. When the test bottles are taken out of the centrifuge, they are again placed in the water bath at a temperature of 60° to 65°C., and left there for several minutes before being read; where the centrifuge is heated, the tubes can be read off as taken from the centrifuge.

By carefully screwing in the rubber stopper, or even by pressing it, the lower limit of the fat column is brought onto one of the main divisions of the scale, and then, by holding the test bottle against the light the height of the column of fat can be accurately ascertained. The lowest point of the meniscus is taken as the level when reading the upper surface of the fat in a sample of whole milk, and the middle of the meniscus for separated milk.

If the column of fat is not clear and sharply defined, the sample must be again whirled in the centrifuge.

Each division on the scale is equivalent to 0.1 per cent., so it is very easy to read to 0.05 per cent., or, with a lens, to 0.025 per cent. If the number which is read off is multiplied by 0.1, then the percentage quantity of fat in the milk is obtained; *e.g.*, if the number on the scale was 36.5, then the percentage of fat is 3.65. (Milk and Dairy Products," Barthel; translated by Goodwin, p. 71.)

77. Before condemning samples of milk which have fallen outside the limits allowed, the chemist shall have determined, by control ether extractions, that his apparatus and his technique are reliable.

78. *Protein Standard.*—The protein standard for certified milk shall be 3.50 per cent. with a permissible range of variation of from 3 to 4 per cent.

79. The protein standard for certified cream shall correspond to the protein standard for certified milk.

80. The protein content shall be determined only when any special consideration seems to the medical milk commission to make it desirable.

81. It shall be determined by the Kjeldahl method, using the Gunning or some other reliable modification, and employing the factor 6.25 in reckoning the protein from the nitrogen.

*Kjeldahl Method.*—Five cubic centimeters of milk are measured carefully into a flat-bottom 800-c.c. Jena flask, 20 c.c. of concentrated sulphuric acid (C. P.; sp. gr., 1.84) are added, and 0.7 gram of mercuric oxid (or its equivalent in metallic mercury); the mixture is then heated over direct flame until it is straw-colored or perfectly white; a few crystals of potassium permanganate are now added till the color of the liquid remains green. All the nitrogen in the milk has then been converted into the form of ammonium sulphate. After cooling, 200 c.c. of ammonia-free distilled water are added, 20 c.c. of a solution of potassium sulphide (containing 40 grams sulphide per liter), and a fraction of a gram of powdered zinc. A quantity of semi-normal HCl solution more than sufficient to neutralize the ammonia obtained in the oxidation of the milk is now carefully measured out from a delicate burette (divided into 1/20 c.c.) into an Erlenmeyer flask and the flask connected with a distillation apparatus. At the other end the Jena flask containing the watery solution of the ammonium sulphate is connected, after adding 50 c.c. of a concentrated soda solution (1 lb. "pure potash" dissolved in 500 c.c. of distilled water and allowed to settle); the contents of the Jena flask are now heated to boiling, and the distillation is continued for 40 min. to an hour, until all ammonia has been distilled over.

The excess of acid in the Erlenmeyer receiving flask is then accurately titrated back by means of a tenth-normal standard ammonia solution, using a cochineal solution as an indicator. From the amount of acid used the per cent. of nitrogen is obtained; and from it the per cent. of casein and albumen in the milk by multiplying by 6.25. The amount of nitrogen contained in the chemicals used is determined by blank experiments and deducted from the nitrogen obtained as described. (Farrington and Woll, "Testing Milk and Its Products," p. 221.)

82. *Coloring Matter and Preservatives.*—All certified milks and creams shall be free from adulteration, and coloring matter and preservatives shall not be added thereto.

83. Tests for the detection of added coloring matter shall be applied whenever the color of the milk or cream is such as to arouse suspicion.

*Test for Coloring Matter.*—The presence of foreign coloring matter in milk is easily shown by shaking 10 c.c. of the milk with an equal quantity of ether; on standing, a clear ether solution will rise to the surface; if artificial coloring matter has been added to the milk, the solution will be yellow colored, the intensity of the color indicating the quantity added; natural fresh milk will give a colorless ether solution. ("Testing Milk and Its Products," Farrington and Woll, p. 244.)

84. Tests for the detection of formaldehyde, borax, and boracic acid shall be applied at least once in each month. Occasionally application of tests for the detection of salicylic acid, benzoic acid, and the benzoates are also recommended.

*Test for the Detection of Formaldehyde.*—Five cubic centimeters of milk is measured into a white porcelain dish, and a similar quantity of water added; 10 c.c. of HCl, containing a trace of $Fe_2Cl_6$ is added, and the mixture is heated very slowly. If formaldehyde is present, a violet color will be formed. ("Testing Milk and Its Products," Farrington and Woll, p. 249.)

*Test for Boracic Acid* (*Borax, Borates, Preservaline, etc.*).—One hundred cubic centimeters of milk are made alkaline with a soda or potash solution, and then evaporated

to dryness and incinerated. The ash is dissolved in water, to which a little hydrochloric acid has been added, and the solution filtered. A strip of turmeric paper moistened with the filtrate will be colored reddish brown when dried at 100°C. on a watch glass, if boracic acid is present.

If a little alcohol is poured over the ash to which concentrated sulphuric acid has been added, and fire is set to the alcohol, after a little while this will burn with a yellowish-green tint, especially noticeable if the ash is stirred with a glass rod and when the flame is about to go out. ("Testing Milk and Its Products," Farrington and Woll, p. 247.)

*Test for Salicylic Acid (Salicylates, etc.).*—Twenty cubic centimeters of milk are acidulated with sulphuric acid and shaken with ether; the ether solution is evaporated, and the residue treated with alcohol and a little iron-chlorid solution; a deep violet color will be obtained in the presence of salicylic acid. ("Testing Milk and Its Products," Farrington and Woll, p. 248.)

*Test for Benzoic Acid.*—Two hundred and fifty to five hundred cubic centimeters of milk are made alkaline with a few drops of lime or baryta water, and then evaporated to about a quarter of the bulk. Powdered gypsum is stirred into the remaining liquid until a paste is formed, when is then dried on the water bath. The gypsum only serves to hasten the drying, and powdered pumice stone or sand can be used equally well. When the mass is dry, it is finely powdered and moistened with dilute sulphuric acid and shaken out three or four times with about twice the volume of 50 per cent. alcohol, in which benzoic acid is easily soluble in the cold, the fat only being dissolved to a very slight extent or not at all. The acid alcoholic liquid from the various extractions, which contains milk sugar and inorganic salts in addition to the benzoic acid, is neutralized with baryta water and evaporated to a small bulk. Dilute sulphuric acid is again added, and the liquid shaken out with small quantities of ether. On evaporation of the ether, the benzoic acid is left behind in almost pure state, the only impurities being small quantities of fat or ash.

The benzoic acid which is obtained is dissolved in a small quantity of warm water, a drop of sodium acetate and neutral ferric chloride added, and the red precipitate of benzoate of iron indicates the presence of the acid. ("Milk and Dairy Products," Barthel, translated by Goodwin, p. 121.)

85. *Detection of Heated Milk.*—Certified milk or cream shall not be subjected to heat unless specially directed by the commission to meet emergencies.

86. Tests to determine whether such milks and creams have been subjected to heat shall be applied at least once each month.

*Detection of Heated Milk—Storch's Method.*—Five cubic centimeters of milk are poured into a test tube; a drop of weak solution of hydrogen dioxide (about 0.2 per cent.) which contains about 0.1 per cent. sulphuric acid, is added, and two drops of a 2 per cent. solution of paraphenylendiamin (solution should be renewed quite often), then the fluid is shaken. If the milk or the cream becomes, at once, indigo blue, or the whey violet or reddish brown, then this has not been heated or, at all events, it has not been heated higher than 78°C. (172.5°F.); if the milk becomes a light bluish gray immediately or in the course of half a minute, then it has been heated to 79° to 80°C. (174.2° to 176°F.). If the color remains white, the milk has been heated at least to 80°C. (176°F.). In the examination of sour milk or sour buttermilk, lime water must be added, as the color reaction is not shown in acid solution.

*Arnold's Guaiac Method.*—A little milk is poured into a test tube and a little tincture of guaiac is added, drop by drop. If the milk has not been heated to 80°C. (176°F.) a blue zone is formed between the two fluids: heated milk gives no reaction, but remains white. The guaiac tincture should not be used perfectly fresh, but should

have stood a few days and its potency have been determined. Thereafter it can be used indefinitely. These tests for heated milk are only active in the case of milks which have been heated to 176°F. or 80°C. (Jensen's "Milk Hygiene," Pearson's translation, p. 192.)

*Microscopic Test for Heated (pasteurized) Milk—Frost and Ravenel.*—About 15 c.c. of milk are centrifuged for 5 min., or long enough to throw down the leucocytes. The cream layer is then completely removed with absorbent cotton and the milk drawn off with a pipette, or a fine-pointed tube attached to a Chapman air pump. Only about 2 mm. of milk are left above the sediment which is in the bottom of the sedimentation tube.

The stain, which is an aqueous solution of safranin 0, soluble in water, is then added very slowly from an opsonizing pipette. The important thing is to mix stain and milk so slowly that clotting does not take place. The stain is added until a deep opaque rose color is obtained. After standing 3 min., by means of the opsonizing pipette, which has been washed out in hot water, the stained sediment is then transferred to slides. A small drop is placed at the end of each of several slides and spread by means of a glass spreader, as in Wright's method of opsonic index determinations (see author's note at end of the methods).

In an unheated milk the polymorphonuclear leucocytes have their protoplasm slightly tinged or are unstained.

In heated milk the polymorphonuclear leucocytes have their nuclei stained. In milk heated to 63°C. or above, practically all of the leucocytes have their nuclei definitely stained. When milk is heated at a lower temperature the nuclei are not all stained above 60°C. The majority, however, are stained.

87. *Specific Gravity.*—The specific gravity of certified milk shall range from 1.029 to 1.034.

88. The specific gravity shall be determined at least each month.

The Quevenne lactodensimeter is recommended for the determination of the specific gravity. It is made like an ordinary aerometer and divided into degrees which correspond to a specific gravity from 1.014 to 1.040, or only from 1.022 to 1.038, since, by the latter division, a greater space is gained between the different degrees without unduly lengthening the instrument. From such a lactodensimeter one can easily read off four decimal places.

The milk the specific gravity of which is to be determined is well shaken and poured into a high glass cylinder of suitable diameter; the aerometer is dropped in slowly, in order to prevent its bobbing up and down. (The bulb should be free from adhering air bubbles.) The figures on the stem are the second and third decimals of the numbers of the specific gravity, so that 34 is to be read 1.034. For this examination, the temperature of the milk must be 15°C. (60°F.); if it is not, the specific gravity of the milk at 15°C. must be calculated from the specific gravity found and from the temperature, for in milk inspection and analysis this is the standard.

## Methods and Regulations for the Medical Examination of Employees, Their Health and Personal Hygiene

89. A medical officer, known as the attending dairy physician, shall be selected by the commission who should reside near the dairy producing certified milk. He shall be a physician in good standing and authorized by law to practice medicine; he shall be responsible to the commission and subject to its direction. In case more than one dairy is under the control of the commission and they are in different localities, a separate physician should be designated for employment for the supervision of each dairy.

90. Before any person shall come on the premises to live and remain as an employee, such person, before being engaged in milking or the handling of milk, shall be subjected to a complete physical examination by the attending physician. No person shall be employed who has not been vaccinated recently or who upon examination is found to have a sore throat, or to be suffering from any form of tuberculosis, venereal disease, conjunctivitis, diarrhea, dysentery, or who has recently had typhoid fever or is proved to be a typhoid carrier, or who has any inflammatory disease of the respiratory tract, or any suppurative process or infectious skin eruption, or any disease of an infectious or contagious nature, or who has recently been associated with children sick with contagious disease.

91. In addition to ordinary habits of personal cleanliness all milkers shall have well-trimmed hair, wear close-fitting caps, and have clean-shaven faces.

92. When the milkers live upon the premises their dormitories shall be constructed and operated according to plans approved by the commission. A separate bed shall be provided for each milker and each bed shall be kept supplied with clean bedclothes. Proper bathing facilities shall be provided for all employees on the dairy premises, preferably a shower bath, and frequent bathing shall be enjoined.

93. In case the employees live on the dairy premises a suitable building shall be provided to be used for the isolation and quarantine of persons under suspicion of having a contagious disease.

The following plan of construction is recommended:

The quarantine building and hospital should be one story high and contain at least two rooms, each with a capacity of about 6,000 cu. ft. and containing not more than three beds each, the rooms to be separated by a closed partition. The doors opening into the rooms should be on opposite sides of the building and provided with locks. The windows should be barred and the sash should be at least 5 ft. from the ground and constructed for proper ventilation. The walls should be of a material which will allow proper disinfection. The floor should be of painted or washable wood, preferably of concrete, and so constructed that the floor may be flushed and properly disinfected. Proper heating, lighting, and ventilating facilities should be provided.

94. In the event of any illness of a suspicious nature the attending physician shall immediately quarantine the suspect, notify the health authorities and the secretary of the commission, and examine each member of the dairy force, and in every inflammatory affection of the nose or throat occurring among the employees of the dairy, in addition to carrying out the above-mentioned program, the attending physician shall take a culture and have it examined at once by a competent bacteriologist approved by the commission. Pending such examination, the affected employee or employees shall be quarantined.

95. It shall be the duty of the secretary, on receiving notice of any suspicious or contagious disease at the dairy, at once to notify the committee having in charge the medical supervision of employees of the dairy farm upon which such disease has developed. On receipt of the notice this committee shall assume charge of the matter, and shall have power to act for the commission as its judgment dictates. As soon as possible thereafter, the committee shall notify the commission, through its secretary, that a special meeting may be called for ultimate consideration and action.

96. When a case of contagious disease is found among the employees of a dairy producing certified milk under the control of a medical milk commission, such employee shall be at once quarantined and as soon as possible removed from the plant, and the premises fumigated.

When a case of contagion is found on a certified dairy it is advised that a printed notice of the facts shall be sent to every householder using the milk, giving in detail the precautions taken by the dairyman under the direction of the commission, and it is further advised that all milk produced at such dairy shall be heated at 145°F. for 40 min. or 155°F. for 30 min., or 167°F. for 20 min., and immediately cooled to 50°F. These facts should also be part of the notice, and such heating of the milk should be continued during the accepted period of incubation for such contagious disease.

The following method of fumigation is recommended:

After all windows and doors are closed and the cracks sealed by strips of paper applied with flour paste, and the various articles in the room so hung or placed as to be exposed on all sides, preparations should be made to generate formaldehyde gas by the use of 20 oz. of formaldehyde and 10 oz. of permanganate of potash for every 1,000 cu. ft. of space to be disinfected.

For mixing the formaldehyde and potassium permanganate a large galvanized-iron pail or cylinder holding at least 20 quarts and having a flared top should be used for mixing therein 20 oz. of formaldehyde and 10 oz. of permanganate. A cylinder at least 5 ft. high is suggested. The containers should be placed about in the rooms and the necessary quantity of permanganate weighed and placed in them. The formaldehyde solution for each pail should then be measured into a widemouthed cup and placed by the pail in which it is to be used.

Although the reaction takes place quickly, by making preparations as advised all of the pails can be "set off" promptly by one person, since there is nothing to do but pour the formaldehyde solution over the permanganate. The rooms should be kept closed for 4 hr. As there is a slight danger of fire, the reaction should be watched through a window or the pails placed on a non-inflammable surface.

97. Following a weekly medical inspection of the employees, a monthly report shall be submitted to the secretary of the medical milk commission, on the same recurring date by the examining visiting physician.

The following schedule, filled out in writing and signed by himself, is recommended as a suitable form for the attending physician's report:

This is to certify that, on the dates below indicated, official visits were made to the ——— dairy, owned and conducted by ——— of ——— (indicating town and State), where careful inspections of the dairy employees were made.

(*a*) Number and dates of visits since last report. ———.

(*g*) Number of men employed on the plant. ———.

(*c*) Has a recent epidemic of contagion occurred near the dairy, and what was its nature and extent? ———.

(*d*) Have any cases of contagious or infectious disease occurred among the men since the last report? ———.

(*e*) Disposition of such cases. ———.

(*f*) What individual sickness has occurred among the men since the last report? ———.

(*g*) Disposition of such cases. ———.

(*h*) Number of employees now quarantined for sickness. ———.

(*i*) Describe the personal hygiene of the men employed for milking when prepared for and during the process of milking. ———.

(i) What facilities are provided for sickness in employees? ———.

(k) General hygienic condition of the dormitories or houses of the employees. ———.

(l) Suggestions for improvement. ———.

(m) What is the hygienic condition of the employees and their surroundings? ———.

(n) How many employees were examined at each of the foregoing visits? ———.

(o) Remarks. ———.

——— ———,
*Attending physician.*

Date, ———.

Note.—Since these methods and standards were adopted the standard methods of bacteriological analysis of the American Public Health Association quoted in paragraph 65 have been superseded by the methods adopted in 1916. Also, Frost has modified the microscopic test for heated milk given in paragraph 86. (Author.)

**Enforcement of the Milk Code.**—Having adopted an ordinance, the next thing is to enforce it. This duty in most municipalities devolves upon the health officer. In small cities he actually does the inspection and analytical work but in the larger ones it is done under his direction through a bureau of milk control whose chief is very largely responsible for the success of the service. Those who formulate the policy to be adopted in improving the milk supply should recognize that in its last analysis the milk question is a financial problem. An inexorable condition of dairy farmers and milk contractors remaining in business is that they shall make money, therefore any attempt to impose on the milk business such conditions that it becomes unprofitable results either in the failure of the proposed regulatory measures with consequent confusion of their proponents or in forcing good milkmen out of business which, of the two results, is least likely to occur. Not only do pecuniary considerations rule the producers and distributors but the efforts at control are directly limited by the amount of money available for the work. The amount expended by American cities in suspervising their milk supplies is not large. Kelly of the Dairy Division of the U. S. Department of Agriculture in 1913 found that of 162 cities, 22 spent absolutely nothing and in the others the expenditure ranged from $\frac{1}{10}$ ct. per capita per year up to 19 cts. per capita per year. The average amount expended, in cities spending anything at all, was 4.14 cts. per capita per year. These figures included all the moneys put into farm and city inspections, laboratory work, supervisory and clerical work, etc. So, every aspect presents the financial question in the foreground.

**The Milk Supply of a City a Valuable Asset.**—The milk supply of a community should be recognized as one of its important resources, as an asset that should not only be protected but be developed and increased in value. None of the large cities have attempted to estimate the amount of capital that is invested to their benefit in the dairy farms and milk

companies that supply them. Yet logically this would seem to be one of the very first steps to take in attempting to regulate dairying. Probably one reason that it is rarely done is that funds are seldom available to make the necessary surveys. Harding and Brew made the following estimate of the capital invested in supplying milk to Geneva, N. Y., a city of 12,574 inhabitants. The region is one of intensive frûit cultivation and all of the milk producers are engaged in mixed farming.

| | |
|---|---|
| Cows 600 at $80 each | $48,000 |
| Land with buildings, 3,000 acres at $100 | 300,000 |
| Equipment, 3,000 acres at $20 per acre | 60,000 |
| City distributors | 50,000 |
| Total | $458,00 |

This is a dairy capitalization of $36.42 per capita or from the agricultural standpoint of $763 per cow of which the producer furnishes $680 and the retailer $83. These students conclude that the average producer was accepting less than 6 per cent. of the capital invested and that his financial salvation depends upon increasing the productivity of his land to the point where it takes less than 5 acres to support a cow and on increasing the productivity of his cows to where they will give over 2,800 qt. of milk a year. The largest retailer of milk in the district had been in business 8 years and had never paid 7 per cent. on his stock. There is no way of knowing how nearly typical of conditions that prevail by and large throughout the dairy industry these figures from Geneva are, but it is doubtful if conditions in general are better so that it is apparent that the moderate profits yielded by the business make it imperative to carefully consider the cost of conditions it is proposed to impose on the industry and to choose a method of accomplishing any desired reform that will be as inexpensive as possible. If the cost of milk to the consumer did not have to be considered, conditions governing the production and sale of milk might be prescribed that would assure that only milk of superior quality was marketed but raising the price of milk brings it into competition with foods that commonly are excluded because of their cost. Moreover the wages and salaries of city folks are fixed and a rise in price of a food means that they have to restrict its use or perhaps forego it altogether. The problem is not only how to protect the public health from impure milk but how to promote the well-being of the community by getting an abundance of milk at moderate price.

**Personnel of the Milk Inspection Bureau.**—This can only be done by securing the coöperation of all concerned, the producer, the dealer and the public. So, the composition of the staff engaged in enforcing the milk ordinance is important. There is much difference of opinion as to what this should be. It is generally agreed that the men should have some sort of preparation or education for their work but there are difficulties in the

way of securing such men. The two chief ones are that salaries are ridiculously inadequate, and that the positions of inspectors are commonly regarded as the property of political bosses to be used in paying political debts. Added to this is the willingness of the public to be badly served. It seems to believe that clothing a man with public office supplies him with intelligence and ability. It is too stupid to see that a $900 salary gets a $900 man and insures the work being done in a $900 way and it loves to maintain the fiction that it is being served by men of superior ability who toil for love of the work or of the public. Rarely does the public see that its interests are as well worth while committing to the care of well-paid men as those of private interests are. Moreover, the readiness of the public to criticize its officers and to assail them, acts as a further deterrent to men who value their reputations accepting a public job. Some cities have found this attitude does not pay and have enlisted the services of most competent men in the public service and among them are some splendid milk inspectors.

Obviously, the bureau of milk inspection has to be organized with as good men as the standards of the community will permit being employed. For the positions of chemists and bacteriologists men of particular training along these lines must be secured. For the inspection service men who have been schooled in sanitation, in scientific agriculture, as veterinarians or those that have had practical farm experience are promising material to choose from. Unfortunately, knowing how is different from the ability to do and so there are many disappointments. The men who succeed are those who are really interested in the work and it not rarely turns out that some who appear handicapped by lack of special preparation make good. In some offices it is the rule to hire only veterinarians, or physicians, or agriculturalists, or what not. In the opinion of the writer this is bad policy for a well-balanced force needs men of different training. In general it has been found that poor results are obtained by appointing men to the staff who divide their time between the practice of their professions and the work of the bureau. Their position is equivocal and everybody knows it. If it is desired to make use of such men they should be hired to do a particular service.

**Necessity of Defining the General Policies Adopted.**—In proceeding to enforce an ordinance, the first step is to make what is wanted plain. The standards adopted should be clearly defined and they should be explained to producers and consumers. As the outset it should be decided whether a pasteurized or unpasteurized supply is wanted. A reasonably safe supply of the latter type is possible only in the case of towns and small cities whose milk is produced by a few dairymen in the surrounding country. Even the best of such supplies will occasionally furnish milk-borne epidemics of infectious disease. The only effective preventative of such outbreaks is carefully controlled pasteurization.

As the dairies multiply and are located at greater distances from the city the opportunities for the milk to become infected are increased, consequently pasteurization under strict supervision becomes a necessity.

The decision as to pasteurization determines the attitude to be taken on the question of bovine tuberculosis. An unpasteurized milk supply ought to come from tuberculin-tested herds, otherwise the milk will certainly contain living tuberculosis germs and a number of children or young people in early youth will contract the disease. Proper pasteurization gives a high degree of protection against bovine tuberculosis and makes it possible to present the campaign that must be waged against it to the farmers as necessary to protect their herds from the severe losses that the disease inflicts, rather than as a public health measure. More permanent results are obtained if the dairyman can be brought to see that the movement to eradicate the disease is calculated to protect and improve his herds than are possible when the movement seems to him to be an attempt to guard others, by the sacrifice of his property, from a disease whose very existence seems to him mythical.

**Necessity of a General Survey of the Producing Territory.**—Having decided on the general policies of control to be adopted a survey of the dairy situation should be undertaken. The length of winter, the period when the cattle are closely confined in barns should be determined; it should be noted what extremes of heat and cold the herds have to endure and at what time these occur. The amount and distribution of the rainfall, the prevalence of fogs and other weather conditions that may affect the ventilation of the barns, the raising of crops and the health of the herds should be recorded. The general topography of the country bears a relation to the water supply, the drainage, the condition of the roads over which the milk must be hauled, etc.

The character of the people engaged in dairying should be studied. They may be classified according to their occupancy of the land, as to whether they are renters or owners which often determines their ability to make improvements on the property they occupy. They may be grouped according to the kinds of farming they practice; it is much easier to introduce improvements in a district where dairy farming is the principal business than in those where it is incidental to grain growing, fruit growing or other kinds of agriculture. The farms that have and those that have not proper dairy equipment should be noted. The social development of a farming community is important for the condition of its schools, its habits of reading and study, and its opportunities for recreation determine its intelligence and ability to progress. It should be observed how many farmers there are who will welcome inspection, how many who may be inspired to adopt better methods and what proportion, because they will not do so, will have to be eliminated.

General market conditions should be investigated. It should be

determined whether dairying has reached the maximum development possible in the district or whether it may be greatly increased. Whether there is but a single market for the milk or whether there is competition for it between creameries and condenseries or between different cities should be noted.

The breed and character of the cows should be observed and the dominant breeds in the different herds recorded so that it may be known whether to expect milk carrying a good percentage of milk solids or not and whether the need is urgent of a campaign for better herds.

The water supply of the different farms should be examined and its adequacy, permanency, temperature and purity should be determined. The temperature of the water is important for it tells to what degree milk can be cooled on the farm without the use of ice.

The means of transportation should be studied. The distance milk is hauled to the shipping point or to the city should be known and whether it is done in wagons or motor cars and whether coöperative hauling is practised.

An estimate should be made as to whether cost of producing milk is reasonable or whether slovenly diarying or conditions beyond the farmers control make the cost of production excessive.

Finally, the probable value of the farmer's investment in the business and the condition of his property should be noted, in order to judge whether or not the price paid for his milk is sufficient to make it worth his while put in still more capital and to adopt better methods of dairying.

Such observations as these ought to furnish information that will enable the health officer to organize a constructive farm-inspection policy but before any regular inspection or analytical work is started a system of keeping office records should be devised.

**Office Records.**—The importance of this can hardly be overstated for if an office is successful in winning the confidence of the public, questions are constantly asked that can be properly answered only by reference to the records. Therefore, they should be adequate and in a permanent, convenient, usable form. There should be a system of filing correspondence, score cards and complaints. Blank forms should be adopted for licenses, labeling samples, recording analyses, sending out notices, etc. A map should be available showing the location of the divers farms that send milk to the city. Each of these farms should be given a number which should appear on all records pertaining to the farm. In like manner there should be a city map showing the places where milk is sold and these places, too, should be numbered. With a good record system established the general work of the bureau may be laid out.

**Important Phases of Milk Control.**—Regulation and improvement of the milk supply is accomplished by inspection, at frequent stages of its long journey from the cow to the consumer, of the milk and of the methods

employed in handling it, by teaching the consumer how to care for milk and its value as food, by chemical and bacteriological control of the supply, by developing a scheme for detecting the presence of milk-borne contagion and for checking its spread, and finally by stimulating general interest in dairying and dairy products.

**Dairy Farm Inspection.**—Farm inspection is undertaken to make sure that the milk comes from well-fed, healthy cows kept in sanitary surroundings and that the milk is properly cooled and cared for till it leaves the farmer's hands. If the inspection is of the right sort, its value is very great. It must be educative. The farmer is dairying to make money; therefore, he is interested primarily in making his place convenient to work in, in his cow, in feeding, in ensiling, in soiling and in practical farm management. The inspector who can advise him in these matters has an advantage. The farmer's interest in sanitation becomes something more than perfunctory only when he can be shown that it pays. That it does, becomes apparent if the code makes it necessary to attain a certain minimum score to get a license to sell milk and if the high scores are published so that the public gives its trade to the dairymen who make them. The relationship becomes still more clear if contractors give premiums for high scores and low bacterial counts or if the milk is graded. The relationship between the pocket nerve and milk quality is clearly shown by the experience of New York City with grade A milk. The very men who could not be moved by legislation or educatory effort to produce aught but unclean milk are putting out this highest grade of milk now that it commands a better price on the market than ordinary milk. This suggests that a proper function of the department of milk control is to develop a good market for milk and to protect it from the inroads of unfair competition.

In starting dairy inspection a reasonable time should be given farmers and others to make the alterations necessary to comply with the ordinance. A little capital at least and sometimes a good deal is required for the improvements so that it is but fair to proceed slowly. The scoring of dairies should be done in the presence of the farmer and a carbon copy of the score should always be left with him. It is well to establish the rule that complaints about the inspection shall be based on the score card because this precludes paltry charges and leads the dairyman to make a careful study of his score.

It has been said that inspection is good but it cannot be ignored that many farmers do not believe it to be so. They maintain that it is overdone, that they are bothered by a flock of inspectors from the contractors, the cities and the State who are not agreed among themselves, who therefore give contradictory instructions and who are a time-consuming pestiferous lot. In some instances there may be justice in this complaint but the dairies that are underinspected far outnumber those that are

overinspected. It is certainly important that inspectors working in the same district should have like standards and work in harmony. Inspectors for contractors can be very useful by preparing the farmer's mind for the instruction the official inspector has to give. Thus an inspector for a dairy company by discussing bovine tuberculosis thoroughly with the dairymen may put them in a receptive mood to advance the plans of a city or State to fight the disease.

**Inspection of Milk in Transit.**—Inspection of milk in transit is chiefly concerned with seeing that the vehicles it is carried in are clean and sweet, that the milk is sealed to prevent it being tampered with, that it is protected from the sun and dirt and that it is kept cool. Inspection at railroad terminals is usually limited to seeing that the milk arrives at low temperature, to sampling the milk on arrival, to seeing that it is promptly handled and that everything is kept in good sanitary condition. Besides, it is ascertained that the empty cans, etc., are returned clean, unrusted and unbattered.

**Milk Plant Inspection.**—The inspection of milk plants is very important for while the milk that leaves the plant can never be a whit better than that which comes in, it may be considerably worse if it is not handled promptly and properly in clean utensils, unless the plant is kept scrupulously clean and sufficient refrigeration is provided. All plants should be scored on the card gotten up for that purpose by the Federal Government. In case the milk is pasteurized the apparatus needs special attention. Care should be taken to see that continuous temperature recorders are in use and that the milk is exposed for the proper time to the prescribed temperatures. Any indication that repasteurization of milk is practised should be followed up and the custom stopped. Any filthy habits that are observed in the employees should be called to the attention of the manager. The general sanitary environment of the plant should be investigated and it should be determined that the toilet accommodations are adequate and sanitary. The expenses of a milk plant are heavy, consequently the manager usually welcomes suggestions that promise to effect saving. The effort should be made to keep the milk plant in touch both with its producers and the public.

In inspecting city milk plants it should be determined whether the plant itself is suitable for the conduct of the business and whether it is adequately equipped. There is no doubt but that in the past producers have been blamed for all of the dirty milk that finds its way into the city market and the responsibility of the city dealer for a large share of it either has been unrecognized or ignored. In particular, those small city dealers who are attempting to operate on too small capital are accountable for a great deal of it and have been dealt with too leniently. The efforts of a poor man to make a living out of a little milk business excite sympathy, consequently such men have been allowed to conduct

their trade from quarters that were wholly unfit for the purpose and with so little equipment that it was impossible to handle the milk properly. The milk they put out is often of poor quality and their sources of supply are usually unsatisfactory and uncertain. Taken by and large this class of men make a bare living out of the milk trade only by aid of the unpaid labor of the members of the family. So while it seems harsh to shut them out, it is necessary for their own good and for that of the community, for their participation lowers the tone of the milk trade as a whole. A minimum standard of construction and equipment of city milk plants and a minimum score should be required and rigidly adhered to.

**Oversight of the Delivery System.**—It is necessary to keep an oversight over the delivery of milk. If the delivery of dipped or bulk milk is permitted, the effort should be made to have it handled in containers that protect it from the dust of the streets and that make for its being handled in a cleanly manner. This sort of delivery is rapidly disappearing; in many cities both large and small it is absolutely prohibited, delivery in bottles being required. In spite of the loss from breakage and theft, the expense of cleaning and the extra weight of the bottles on the wagon, bottled milk is superseding dipped milk because it offers milk of uniform composition in attractive packages, reduces the loss incident to handling the milk, and minimizes the danger of contamination in delivery. On the whole it is a much safer way of handling milk than to deliver it in bulk, though communities that do not require the daily sterilization of the bottles before they are filled are certain sooner or later to suffer from outbreaks of communicable disease originating in infected milk bottles. There should be a stringent rule forbidding the filling of milk bottles by drivers on the streets.

Delivery of milk in open wagons should be prohibited. The wagons should be kept clean and in good order. The noisy delivery of milk in the early morning hours is a veritable nuisance which some cities deal with by ruling rattlety wagons off the street and requiring all wagons to be rubber-tired. The drivers should be neat and clean and should be sharply brought to book if detected in handling milk carelessly.

The provisions of the code pertaining to labeling should be enforced. The wagons should carry the name of the dairy or of the owner in large plain letters and the license number in bold figures. Some cities require that the name of the dealer be moulded in the bottle and forbid dealers using one another's bottles. If skim-milk, subnormal milk, or milk beverages are carried on the delivery wagon, their containers should be marked conspicuously as to their content. If the law requires that the grade of milk or information regarding the pasteurization of milk be marked on the bottle cap, the caps should be approved by the department

of milk control. A firm stand should be taken against false or misleading labeling.

The bureau should be informed as to whether one or two deliveries a day are made, approximately the territory each dealer covers, the number of wagons he employs, the length of time the milk is on the wagon, its temperature when delivered to the consumer and what is done with the milk that is returned undelivered to the milk plant. It should be assured that the regulations in regard to the removal of bottles from premises harboring cases of communicable disease are complied with.

*Courtesy of J. O. Jordan.*

FIG. 61.—Sale of dipped milk in a small shop. Note that the top of the milk tank is foul from milk splashings.

**Sale of Milk in Stores.**—The sale of milk in stores ought to be closely watched. Generally it is small provision stores in the poorer and more congested parts of the city that deal in milk and usually they carry it rather for the accommodation of their patrons than with the expectation of making money out of it; therefore, they take little care of it. The stores themselves are often poorly furnished and cluttered with all sorts of small merchandise, consequently they are unclean and smelly. In short, the sale of milk in them is to be tolerated rather than encouraged. Yet they do considerable trade. The replies to letters of inquiry sent out by the U. S. Department of Agriculture in 1911, to 47 cities having an aggregate population of 451,239, showed that these cities averaged 1,256 milk-selling stores or one store to every 359 inhabitants. Of these

stores, 52.4 per cent. sold only bottled milk, while the rest, or 47.6 per cent., sold dipped milk. In 17 cities reporting, the dipped milk sold over the counter per day amounted to 231,896 gal., or 13,641 gal. per day in each city permitting the practice.

There are numerous objections to the sale of dipped milk. It is apt to be stale because drivers commonly deliver that milk which has been longest on the wagon to the stores and the fresh milk to the family trade. Even if the intention of the dealer is honest the quality of the milk served to different customers will vary considerably; some will get rich milk from the top of the can and others will get skim-milk from the bottom. A more weighty objection to the sale of dipped milk is found in the records of several cities which show that the samples of dipped milk from stores are much more commonly adulterated in other ways than by skimming than are the samples from wagons. Besides being liable to sophistication dipped milk is exposed to contamination with all sorts of dirt. Often facilities for cleaning the milk utensils are lacking and so the dipper and measure get into shocking condition; sometimes a cheesy layer of casein accumulates at the edges of the milk tank and sediment collects on the bottom. Most serious of all is it, that the milk is repeatedly exposed to human contamination and therefore is likely to become infected with the germs of human disease. The proprietors of the stores are often ignorant and have no conception of the way milk should be handled and so it is insufficiently iced or iced not at all. The result is the bacterial content of dipped milk is likely to be very high. Thus in Boston in 1908, only 27.85 per cent. of the wagon samples contained more than 500,000 bacteria per cubic centimeter, whereas 56.59 per cent. of samples of dipped milk ran over this figure.

Some cities absolutely prohibit the sale of dipped milk but not all are able to do so. Its sale has to be tolerated because the very poor cannot purchase bottled milk and find the dipped milk a convenience. These people buy a few cents worth of milk at a time, take it home and use it at once. Even if they could afford to buy milk by the bottle, they have no way to keep it cool so that most of it would spoil before being used. In some places this difficulty is met by selling milk to stores in ½-pt. bottles. Undoubtedly one of the reasons that both milk dealers and storekeepers are loth to discard the sale of dipped milk is that serious loss is suffered from the non-return of bottles. Where this can be controlled by requiring a deposit for the bottle much of the opposition to the discontinuance of the sale of dipped milk disappears. Generally the effort of the department should be to gradually eliminate the sale of dipped milk and meanwhile to control the sale by scoring the stores on the score card devised by the U. S. Department of Agriculture and by frequent inspections.

When dealers substitute the sale of milk in bottles for that of dipped milk they soon are pleased with the change, for the bottles are easy to

SANITARY INSPECTION OF STORES HANDLING BULK MILK, U. S. DEPARTMENT OF AGRICULTURE, BUREAU OF ANIMAL INDUSTRY, DAIRY DIVISION

DETAILED SCORE

| Equipment | Score | | Methods | Score | |
|---|---|---|---|---|---|
| | Perfect | Allowed | | Perfect | Allowed |
| Building | | | Building | | |
| Location: Free from contaminating surroundings.. | 2 | ........ | Cleanliness................ | 10 | ........ |
| | | | Floor.................. 3 | | |
| Separate room for milk handling............... | 5 | ........ | Wall.................. 2 | | |
| Construction............... | 8 | ........ | Ceiling............... 2 | | |
| Floors tight, smooth, cleanable............ 1 | | | Show cases, shelves, etc. 3 | | |
| Walls tight, smooth, cleanable............ 1 | | | Freedom from flies......... | 3 | ........ |
| Ceilings tight, smooth, cleanable............ 1 | | | Freedom from rubbish...... | 2 | ........ |
| Show cases smooth, free from ledges and crevices 1 | | | Air......................... | 4 | ........ |
| | | | Freedom from dust....... 2 | | |
| Provision for light (10 per cent. of floor space) 1 | | | Freedom from odors...... 2 | | |
| Provision for pure air.. 1 | | | Utensils.................... | 20 | ........ |
| Screens............... 2 | | | Thoroughly washed and rinsed................10 | | |
| Utensils.................... | 15 | ........ | Steamed................10 (Scalded, 5.) | | |
| Construction: Easily cleaned; free from open seams and complicated parts................. 5 | | | Ice box..................... | | |
| Condition: Free from rust, dents, etc............. 2 | | | Cleanliness of ice box....... | 3 | ........ |
| Facilities for cleaning: | | | Handling: | | |
| Water clean, convenient, and abundant....... 2 | | | Placed on ice as soon as received.................. (Protected, put on ice inside of an hour, 2.) | 5 | ........ |
| Hot water or steam.... 3 | | | | | |
| Brushes and washing powder.............. 1 | | | (Unprotected, but put on ice inside of an hour, 1.) | | |
| Protected from flies and dust when not in use... 2 | | | | | |
| | | | Temperature of milk, below 50°F............... | 10 | ........ |
| Ice box..................... | | | (51–55, 8; 56–60, 5; 61–65, 2.) | | |
| Separate ice box for milk . 5 | 10 | ........ | Freedom from undue exposure to air............ | 2 | ........ |
| (Milk kept in separate compartment, 2.)........ | | | Cleanliness of attendants..... | 1 | ........ |
| Construction............ 3 | | | | | |
| Tight and cleanable.... 1 | | | | | |
| Non-absorbent lining... 1 | | | | | |
| Good drainage......... 1 | | | | | |
| Protected from flies and dust................. 2 | | | | | |
| Total..................... | 40 | ........ | Total................. | 60 | ........ |

Equipment.......... + Methods.......... = Total..........

NOTE.—If the conditions in any particular are so exceptionally bad as to be inadequately expressed by a score of "0," the inspector can make a deduction from the total score.

handle and friction with the authorities over skim-milk, etc., is reduced to a minimum.

In Massachusetts the State Supreme Court found that the Board of Health of the City of Boston had exceeded its powers in prohibiting the sale of dipped milk, but before the decision was announced the ordinance had been in force long enough to demonstrate its wisdom and no one has cared to resume the sale of milk in bulk.

Stores selling bottled milk must needs be inspected, too. It is important to see that bottles are not filled on the premises and that the practice of splitting bottles of milk is not indulged in. It must be ascertained that the milk is stored properly for there is danger that the bottles may stand around the store uniced. Stores selling bulk milk should be scored on the Federal Dairy Division score card, designed for that purpose.

**Milk in the Home.**—By attention to these various phases of the dairy business, health departments reach the dairy farmers, the milk contractors and the vendors of milk and help them to serve the public with milk of good quality. It remains to interest the milk consumers and to get them to do their part in maintaining a good milk supply. Some boards do this by issuing leaflets on the value of milk as a food, on the care of milk in the home and like topics. The effort is made to get the housekeeper to realize that the best of milk will spoil quickly unless it is kept properly and so that if she is neglectful her family must be content with poor milk. In some places the misuse of milk bottles has been greatly lessened by urging people to be careful to return them whole and clean and by pointing out that excessive waste of bottles tends to raise the price of milk. Sometimes boards have helped the public by showing it to be impossible to sell good milk at prevailing market prices and helping to establish rates high enough for the dairymen to be clean and honest. Wherever boards win public confidence they are frequently consulted as to the quality of milk put out by different dealers. To answer such questions the board must have a laboratory and make many milk analyses.

**Laboratory Tests.**—The States, most of the large cities and many of the small ones support laboratories for bacteriological diagnosis and the testing of foods including milk. Indeed, this sort of work has become so important that to secure its benefits contiguous towns not large enough to support laboratories of their own combine and support a single laboratory that serves them all. The milk tests that are commonly made in these laboratories are of three principal kinds, namely: physical, chemical and biological. The object in applying these tests is to keep dirty, decomposed and adulterated milk off the market.

**Sediment Test.**—The two principal physical tests of milk are the sediment and the lactometer tests. In fact, many small towns that cannot afford laboratory facilities rely solely on these two tests to keep

dirty, watered and skimmed milk off the market. That they in some measure do this is not to be doubted but the sediment of dirty milk can be greatly reduced by careful straining and by centrifugalizing the milk, and milk can be doctored by the use of condensed milk and by other means to meet the lactometer test so that only in a limited way do these tests detect dirt and fraud. The sediment test is usually performed by passing a pint of milk through a Wisconsin or a Wizard sediment tester. The sediment is caught on cotton disc which may be dried and preserved. The test is one that every dairyman can grasp the meaning of and it has been used very effectively not only by city officials but by creameries and cheese factories to get cleaner milk. It is the practice of some offices to mail excessively dirty discs to the offending producer with an injunction that he mend his ways. Some health officers preserve the discs and mount them on a card to be filed as part of the permanent record of the dairyman; others at intervals prepare a mount of the discs of all the dairymen in town and display it in the health office or in some store window where all who pass can see it.

**Lactometer Test.**—The lactometer is a float for taking the specific gravity of milk. There are two lactometers in use in this country, the New York Board of Health and the Quevenne; they differ principally in the scales on the stem for reading the specific gravity. The Quevenne is probably in most general use; on its scale most normal milks give readings between 30 and 34.

**Chemical Tests.**—The chemical determinations that are ordinarily made in examining milk are the butterfat, the total solids and the ash. The solids-not-fat are obtained by difference. The acidity of milk is easily determined by titrating it with an alkali and with phenolphthalein as an indicator. The acidity is usually expressed as percentage of lactic acid. In the larger laboratories, if skimming is suspected, proteins are determined by the Gunning method, if watering the refraction of the serum, the lactose, the soluble albumen, and the sour serum ash.

**Tests for Preservatives.**—Tests for preservatives in milk are made at most laboratories. Formerly this kind of adulteration was very common but partly because of the vigor of the campaign against it and partly because dairymen have learned to produce milk that will keep, the doping of milk has gone out of fashion. The preservatives most commonly used are formaldehyde, borax, borates, boracic acid, salicylic acid, benzoic acid, benzoates, sodium bicarbonate, fluorids, hydrogen peroxid (Buddeized milk), nitrates, potassium bichromate, etc. To cream, calcium sucrate (viscogen) is sometimes added to thicken it; so is gelatin and possibly starch. Anatto and the coal-tar dyes, principally the azo-colors, are sometimes used to make milk look rich.

**Biological Tests.—Determination of the Cellular Content.**—Biological examination of milk is divided into two parts, namely: the determination

of the cellular content, and the bacteria. For the former the methods of Prescott and Breed, of Doane and Buckley as improved by Hastings, or of Stewart are used. Of the three the Stewart method is the least exact. However, it is the most convenient and the information obtained from the microscopical examination—of the smeared sediment, although it is not accurate enough for quantitative work, is satisfactory for qualitative examinations and so has proved very helpful in routine laboratory practice. Slack first advocated a microscopical estimate of bacteria by an adaptation of the Stewart method for cells. The method of Prescott and Breed shows the greatest number of cells and has the advantage that the smear can be used also for microscopical counting of bacteria.

Stokes and Wegefarth in 1897 called attention to the leukocytes in market milk and took the ground that milk containing more than five leukocytes to a field of a 2-mm. objective was unfit for use. They spoke of the leukocytes as pus cells and the inference was widely drawn that the presence of large numbers of these cells indicated that the milk came from cows with inflamed udders. Subsequent investigations showed this view to be fallacious; cows giving no history of udder trouble and in perfectly normal health were found to give off body cells which are mostly leukocytes but partly epithelial cells, at times in great numbers. The leukocytes themselves occur normally in the blood and lymphatics and make their way from these into most of the other body tissues so that they can be correctly spoken of as pus cells only when they can be shown to be derived from suppurative discharges.

It is generally accepted that if the Stewart-Slack smear shows the intimate association of long-chain streptococci with bunched leukocytes, it may be safely concluded that the organisms are pyogenic streptococci derived from cases of garget and that the milk should be withheld from the market until the affected animals are located and removed from the herd. The health department of the city of Boston, Mass., began excluding milk from the city on this test in 1905. That year 10.5 per cent. of the 5,500 samples of market milk examined were found infected with the streptococci. At that time milk was excluded that showed "pus" without streptococci or streptococci without "pus," later a more conservative attitude was taken and only milk showing pus, or bunched leukocytes associated with streptococci was excluded. In 1906 the number of positives dropped to 4.9 per cent. and in 1907 to 1.1 per cent. and has remained less than 2 per cent. ever since, usually being about 1 per cent. Many times the justice of the Board's action has been confirmed by tracing the milk back to the farm that supplied it and finding cows with diseased udders in the herd.

In making bacterial counts by his method, of milk brought in by farmers, Breed very recently has found enormous numbers of long

chain streptococci in some of the milk, and in every instance where he traced it back to the farm, found one or more infected udders in the herd, but of 9,387 cows that he examined 309 or 3.3 per cent. were positive; 4 out of 40 herds supplying the milk were badly affected and but 8 out of the 30 dairymen who furnished milk continuously for twenty months did so without bringing any streptococcic milk.

Garget due to streptococcal and to other bacterial invasions of the udder is very common, but from our present knowledge of septic sore throat there is no reason to believe that the disease is derived from the ordinary run of garget cases. Practically always, it seems to be due to the Smith streptococcus which may infect the cow's udder from human sources. Outbreaks of diarrhea have been produced by streptococci coming from the udders of cows suffering with mammitis. So there is good reason for removing cows with udder trouble from the herd. When such animals shall be returned to the herd is usually left to the judgment of the herdsman, who makes his decision on the appearance of the udder and of the milk. The wisdom of this procedure is doubtful for the infective organisms often persist long after physical evidence of their presence has disappeared.

**Biological Test for Heated Milk.**—Frost has proposed the following method for detecting pasteurized milk by direct microscopical examination. One part of a saturated aqueous solution of methylene blue is slowly added from a pipette to 5 parts of milk, the milk being rotated in a flask during the addition to prevent coagulation of the milk which vitiates the test. After 15 to 30 min. the stained milk is centrifuged in Slack tubes or ordinary urine tubes and the sediment is smeared on glass slides and dried when the smear is ready for examination.

The stain is made up by adding 7 grains of Gruebler's dry dye to 100 c.c. of distilled water and allowing it to stand several hours with frequent shakings. Finally, it is filtered.

The differentiation between pasteurized and unpasteurized milk depends upon a twofold change effected by heat on the leukocytes, viz.: (1) it alters the shape and size of the cells; and (2) it changes their staining reactions.

The smear from the unpasteurized milk under the low power of the microscope gives a light blue field in which the depth of the stain depends on the thickness of the film but which very uniformly is stained more highly than any of the smaller objects in the field. The oil immersion lens shows the mononuclear cells well-stained and they are not considered in this test.

The polymorphonuclear cells are distinguished with some difficulty and appear colorless, of irregular outline and $12\mu$ in diameter. If the nuclear material is differentiated at all, it is not well-defined.

The smear from pasteurized milk under low power appears less

deeply stained, excepting the thick portions, than the unheated milk and the leukocytes take the stain more deeply than the background so that they appear as dark blue areas in a light blue field. Often there is a halo about the leukocytes owing to the background immediately surrounding them staining deeply and shading off into the general color of the smear. The oil immersion lens shows the polymorphonuclear cells readily, with less irregular outline than those of the raw milk and shrunken to about $7\mu$ in diameter. The nuclei are distinctly stained. The amount of the shrinking and the depth of the stain vary some with the degree of heat applied. The shrinking of the cells begins at a lower temperature than that used for pasteurization and their shape gradually changes as the degrees of heat increase. The fixing of the nuclear material which makes possible the absorption of the stain seems to take place at between 140° and 145°F., the temperature used in the holder process of pasteurization. The changes Frost points out as characteristic of heated milk are observable in the Stewart-Slack smears, so those that use them say, and they hold that the smears may be used for detecting heated milk.

**The Bacteria Count.**—It is but recently that the bacterial content of milk has been used as a criterion of milk quality. The first bacterial count of a municipal milk supply to be published in the United States were those of Sedgwick and Batchelder who in 1892 gave out the results of their study of the milk of Boston. At about the same time Conn published the counts he obtained in investigating the milk supply of Middletown, Conn. Other bacteriologists took up the work and before long many cities were making regular bacteriological examinations of the milk served the public. Montclair, N. J., was the first municipality to regularly publish the results of such examinations. There the effect was that the public became interested at once and began to favor those dealers whose milk had low counts. Soon cities began to establish bacteriological milk standards. Thus New York City in 1900 adopted a maximum limit of 1,000,000 bacteria per cubic centimeter and Boston a little later established a limit of 500,000 bacteria per cubic centimeter. Other cities followed so that in 1914 the U. S. Public Health Service was able to publish a list of 149 cities, each having a population of over 10,000 and having together a population of somewhat over 21 million, that had set up bacteriological standards of some sort.

There is no question but that the bacterial count has been very effective in improving many milk supplies. The result of publishing counts has been to focus public attention on clean methods of milk production and on the proper care of the milk and this has reacted on producers and dealers, making them emulate the methods of the best dairymen. Notwithstanding this, some bacteriologists question the wisdom of laying great stress on the bacterial count on the ground that it is inexact and illogical.

**Methods of Making the Bacterial Count.**—There are three methods of making bacterial counts, namely: (1) by the plate method of Koch; (2) by the direct method of counting the bacteria in a smear prepared according to the Breed method, or by the less accurate method of Slack; and (3) according to the stained incubated slide method of Frost. The Koch method is the standard one; it consists of growing the organisms at a chosen temperature and for a definite time usually at 68°F. for 48 hr. in specially prepared nutrient media in petri dishes and counting the organisms that develop. The summary of the advantages and disadvantages of the Breed and of the Koch plate methods as given by Brew appears in Table 117.

TABLE 117.—THE DISADVANTAGES AND ADVANTAGES OF THE MICROSCOPICAL AND METHODS OF PLATE MAKING BACTERIAL COUNTS COMPARED (BREW)

| Breed method | Plate method |
|---|---|
| **Disadvantages** | |
| 1. Difficult to measure so small a quantity of milk accurately. | 1. All bacteria do not grow on the plates because of changes in food, temperature relations or other conditions of environment. |
| 2. The sample measured is too small to be representative. | 2. The difficulty of breaking up the clumps in the milk affects the accuracy of the count. |
| 3. Dead bacteria may be counted. | 3. Requires from 2 to 5 days' incubation period. |
| 4. Error of count is great where bacteria are very few or many. | 4. Different species require different incubation temperatures. |
| 5. Cannot be used for quantitative work when the bacteria are few in number. | 5. Gives no idea of the morphology of the organisms present. |
| 6. Many fields must be counted, because of the uneven distribution, if an accurate count is required. | 6. More apparatus is required; therefore, is more expensive. Technique complicated and difficult for trained bacteriologists to use in such a way as to get consistent results. |
| 7. Large compact clumps cannot be counted. | |
| 8. Bacteria may be lost in process of preparing slides. | |
| **Advantages** | |
| 1. Less apparatus required, therefore less expensive. Technique simple. | 1. Is necessary for isolation of pure cultures. |
| 2. The results on a given sample can be reported within a few minutes. | 2. Gelatin shows the liquefiers and if litmus is used, the acid producing bacteria. |
| 3. Shows the cell content, the presence or absence of streptococci and other important things necessary in estimating the sanitary quality of milk. | 3. Shows character of growth. |
| 4. Gives a better idea of the actual number of germs present. | 4. Shows living organisms only. |

There are two ways of counting the Breed smears. By one method each cell in a chain of streptococci or in a clump of bacteria is counted, with the result that roughly about 10 times the number of bacteria shown by

the plate method, are found. By the other, each clump and each chain of streptococci is counted as a unit. The latter method usually gives much lower counts and corresponds more closely with the plate count; it is the method adopted by the Bureau of Chemistry in milk work when the microscopical method is used. The Slack method shows approximately as many bacteria as the plate method does.

The standard methods adopted by the American Public Health Association in 1916 make the plate method the standard one but the usefulness of the Breed method in certain lines of milk work is recognized and its use advised when direct counting is undertaken.

In the stained incubated-slide method recently proposed by Frost, $\frac{1}{20}$ c.c. of milk is mixed with standard nutrient agar and spread over a definite area of a sterile glass slide. When the agar is hard, this little plate culture is put in the incubator for about 6 hr. under conditions that prevent evaporation. It is then dried, given a preliminary treatment to prevent the agar from firmly binding the stain, stained, decolorized and cleared. When the dried and stained plate culture is viewed under the microscope the little colonies are definitely stained and appear highly colored on a colorless or slightly colored background. The colonies can be readily counted and the number of bacteria per cubic centimeter calculated.

**Accuracy of Bacteria Counts.**—It has long been known that dissimilar bacteriological results are frequently obtained when samples of the same milk are submitted to different laboratories for examination. It was felt that these discrepancies were in large part due to slight differences in the media used and also to variations in technique that obtained in different laboratories; so that American Public Health Association published Standard Methods of Milk Analysis which have been generally accepted throughout the United States. In spite of these methods being used, divergent results continued to be obtained and this, in 1914, led four laboratories in New York City, viz., the New York City Public Health, the Borden, the North and the Lederle laboratories to ask H. W. Conn of Wesleyan University of Middletown, Conn., to act as referee of a coöperative test that lasted 7 months and involved the making of about 20,000 bacterial analyses by various methods with the object of determining whether the discrepancies are due to inevitable difficulties in bacteriological analysis, or whether such analysis has such inherent obstacles that it cannot be made reliable, or whether the different methods of technique employed in the several laboratories were responsible for wide variations in the result. In case differences in technique proved to be a factor of considerable moment, it was the intention to determine how nearly identical the various methods might be made and what error in bacteriological milk analysis would still remain. The general summary and conclusions arrived at from the test are these:

"1. The standard methods of Milk Analysis, published by the American Public Health Association, are in emphatic need of revision. These standard methods lay great emphasis on some of the least important points, while they neglect to lay any emphasis on some of the most important ones. The revision of these methods is now in the hands of at least three committees, one appointed by the American Public Health Association, one by the Society of American Bacteriologists, and one by the Association of Dairy Instructors. (Revision of 1916 has since been adopted.)

"2. Individual analyses under the best conditions are subject to considerable variation, so that no single individual count can be properly relied upon. This emphasizes the necessity of demanding an average of two or more plates in determining the bacterial content of any sample of milk.

"3. The question of the exact composition of the media to be used is of far less significance than that of the methods used in the manipulation. Wide variations in the composition of the media do not make any noticeable difference in the bacterial count.[1]

"4. Greater care is needed to unify laboratory methods than has hitherto been given. When the work of these four laboratories was compared at the outset it was found that there were very wide differences in the analyses of duplicate samples, due chiefly to differences in laboratory technique.

"5. These variations in the analyses of duplicate samples of the same lot of milk have been found to be due to several causes:

"(*a*) Laboratory errors. These occasionally appear, due doubtless to confusion which is sure to arise when large numbers of samples of milk are analyzed at the same time.

"(*b*) Irregularities in methods of laboratory technique. These are several in number, the more important seeming to be the following:

"I. Shaking of the samples. Wide variations were found in the vigor and the extent of the shaking to which the samples of milk and the dilutions are subjected by the different laboratories. While this factor does not make a very great difference in results, it is one of the irregularities that should be eliminated.

"II. Amount of dilution. The counts from highly seeded plates are uniformly lower than the counts of the same milk from low-seeded plates. The best results are obtained only when the plates contain somewhere between 40 and 200 colonies. Hence the number of dilutions made in any analysis will materially affect the results.

"III. Methods of counting. This has seemed to be the cause of the widest amount of irregularity. The greatest difference was associated with the use or non-use of a counting lens, or to differences in magnifying power of the lens used.[2]

"Even when this difference is eliminated the further results show that the personal equation in counting is still a factor of very large importance. When

[1] For this reason and in order to produce uniformity, there has already been adopted by the American Public Health Association a change in the standard methods by which beef extract can be substituted for beef infusion and the acidity of the standard agar fixed at 1 per cent., thus making it uniform with that of the standard used in water analyses.

[2] The recognition of this fact has already led to a modifying of the standard methods, which now require a lens of 3½ diameters to be used in counting all plates.

the same plate is counted by two different laboratories the results are not infrequently 100 per cent. apart, and occasionally even more.

"A third factor modifying the counting is the method adopted by each laboratory of estimating numbers rather than actual counting. In plates that contain large numbers of colonies it is, of course, necessary to make an estimate rather than to count them all. The laboratories adopt different methods in such conditions, the results being slightly different.

"IV. Irregularities in samples from the same bottle of milk. Two samples taken from the same bottle of milk, even after thorough shaking, are by no means identical. This is easily explained, and is due (1) to the clumping of bacteria and (2) to the fact that inasmuch as bacteria are not in solution but are solid objects they cannot be expected to be uniformly distributed through the liquid. The tests show that one sample of a bottle of milk when tested by the plate method may sometimes not contain more than one-fourth as many bacteria as other samples from the same bottle.

"V. In low counts variation between duplicate samples is sometimes considerable, due to the irregularity of the distribution of bacteria.

"In high counts variation in reports is also sometimes very great, due to excessive crowding and to methods adopted in estimating the number of colonies.

"6. The extent of the variation in the results obtained from the analysis of duplicate samples varies widely with the care that is taken in the laboratory technique. It has been found in these tests that at first the above causes of irregularity were sufficient to give results disagreeing as much as tenfold in the number of bacteria that would be reported from any sample of milk. The vast majority of results, however, were much closer than this, even at the beginning of this series of tests.

"7. After attention had been called to the points of irregularity and the laboratories had adopted methods of bringing about uniformity in technique so far as possible, the variations were very greatly reduced, the last tests showing that when sufficient care is given the variations need not be more than twofold. It is not possible to rely upon a greater accuracy than 100 per cent. even when an average of more than one analysis is obtained, although most of the results fall considerably below this limit.

"8. There is no essential difference in the results whether milk dilution is directly inoculated into the petri dish and the agar poured upon it, or whether the milk dilution is inoculated into the melted tube of agar and subsequently poured into the petri dish. The difference between the two methods is so slight as to make it impossible to determine which is the superior of the two. But when examinations of cream are made the plate inoculation is unreliable, and the inoculation must be made in the agar tube followed by thorough agitation.

"9. Five days' incubation (48 hr. at 37° and 72 hr. at 20°) gives a very slightly greater count than a 2-day incubation. The increase in count is so slight that for general regulation purposes it is hardly superior to a 2-day count; and considering the superior value of obtaining the count promptly there seems to be no reason for changing from a 2-day count to a 5-day count.

"10. A 24-hr. count gives on the average about one-half as high numbers as a 48-hr. count.

"11. In spite of all these irregularities the results with duplicate samples in

the four laboratories have been found, within certain somewhat wide limits, fairly accurate. They are at all events accurate enough to warrant three broad grades, essentially three grades that have been adopted by the commission on milk standards. But they are not as yet accurate enough to warrant a closer grading than the commission's grades, A, B, and C, A including all below 200,000 (or 100,000), B from 200,000 to 1,000,000, and C including all above 1,000,000. For this broad grading it is necessary to have an average of at least four or five separate analyses in order to rely upon the results. Even then there will be an occasional overlapping of grade B with either grade C on the one hand or grade A on the other.

"12. This series of tests has proved that if a sample of milk can be put into iced water, containing floating ice, it may be kept for 20 hr. with very little change in bacteria count. This makes it possible to keep samples sent to a laboratory for analysis for a number of hours without any fear of change in bacterial content, provided the samples are immersed in water containing floating ice.

"13. These tests have seemed to indicate that the American peptone, made by the Digestive Ferment Co., of Detroit, can be substituted for Witte peptone without materially changing the results.

"14. *Direct Microscopic Method of Bacterial Examination of Milk by the Breed Method.*—In making a comparison of the bacteriological analysis by the plate count and the microscopic count, the latter should be a count of groups rather than individuals, plate colonies representing groups only.

"15. Considerable experience by the person making the count is needed to distinguish between bacteria and dirt particles, particularly when the milk contains minute micrococci.

"16. When the microscopic count is made by one who has had sufficient experience, the group count agrees somewhat closely with the plate count—agreeing, indeed, about as closely as the plate counts of different laboratories agree with each other.

"17. Raw, fresh milk does not contain any appreciable number of dead bacteria which might disclose themselves to the microscope, but fail to grow in plates.

"18. The direct microscopical examination of milk smears by the Breed method will classify raw milk into grades A, B, and C with about the same accuracy and much more quickly than the plate method of bacteriological analysis will do. It is of no use in the study of pasteurized milk, however, since it discloses dead as well as living bacteria, no method of distinguishing between them having yet been perfected. It might be of value in telling whether such milk had become old before it was pasteurized, since such would show large numbers of dead bacteria by the microscopic method, though it might show small numbers by the plate method.

"19. The direct microscopical method of bacteriological analysis might be of exceptional value applied at the dairy to guide the dairyman as to the general grade of the milk he is marketing. It may also be of great aid to the large dealer to enable him to determine promptly whether he is purchasing milk of A, B, or C grade. The possibility of quick results and ease of making the smears at the dairy or shipping station, subsequently sending them to the laboratory for microscopic examination, renders the method especially applicable at the dairy end of the line."

These difficulties in bacteriological analysis are fully recognized and competent analysts give them due consideration in interpreting results. Consequently objections to the bacterial count based on these discrepancies merely amount to the charge that the method is not refined enough to warrant so much stress being put on its use. The validity of this accusation, of course, depends on the way the analyses are interpreted and to the uses they are put. There is no doubt but the attempt has been made, particularly by untrained officials, to draw too fine distinctions from bacteriological findings and it is equally certain those who know how to use them find them sufficiently accurate to enable them to classify the milks of the various dairymen with whom they are dealing and to help correct the shortcomings of some of them. But objections to the bacterial count are not limited to these inaccuracies; it is held by some to be irrational, as applied to raw milk.

**Some Factors That Should be Considered in Using the Bacterial Count.**—The point is made that it is the kind of bacteria, to wit, the disease germs and not the number present, that is important for it is not only possible but even probable that in most instances in which milks show high counts the microbes are perfectly innocuous forms such as the lactic acid germs, whereas it is conceivable that a milk carrying but few bacteria may be infected with disease germs. To this it is replied that in the case of children there is evidence that their tender intestinal tracts may be overwhelmed by mere numbers of microörganisms and also that large numbers of bacteria in milk indicate that it has been produced under filthy conditions or has been mishandled.

When milk is sampled on the farm and plated shortly thereafter, the bacterial count is within limits a measure of the amount of contamination the milk is receiving for the germs are largely those that are introduced from fecal matter, the hands of the milker, the feed, the utensils, etc., but as time lapses this is no longer true for then the bacterial count is the result not of a single factor but of three, namely, of dirty dairying, of high temperature and of age. It is pointed out that in winter, or in summer as a result of liberal icing, the milk of a dirty dairyman may compare favorably, so far as the bacterial count is concerned, with milk produced by dairymen who are scrupulously clean. Also, it is contended that the count so far as it is indicative of dirt, does not distinguish between human dirt, which is most likely to be harmful, and animal dirt, which is comparatively harmless. In reply to these allegations it is admitted that cold for a longer or shorter time may keep down the bacterial counts of an unclean dairy to the average of those of clean ones but it is maintained that fluctuations in the count of the milk of the dirty dairy, owing to failure to always maintain low temperatures, are bound to occur with sufficient frequency to direct suspicion to the milk and ultimately to condemn it. Furthermore, it is maintained that while it is

true that slovenly dairying, lack of refrigeration and age may individually or in combination produce high counts it is not essential although it would be desirable to distinguish which, in any particular case, is responsible for high numbers of bacteria. Milk as drawn from the udder normally contains few bacteria and these are of varieties that do not multiply rapidly in milk, consequently if it contains large numbers of

FIG. 62.—Effect of temperature upon milk as shown by bacterial counts.

Fig. 1.—Original sample.

| | 42° F. | 72° F. |
|---|---|---|
| After 4 hours | Fig. 2 | Fig. 5 |
| After 9 hours | Fig. 3 | Fig. 6 |
| After 30 hours | Fig. 4 | Fig. 7 |

(*From the 14th. Annual Report of the Board of Health of the Town of Montclair, N. J.*)

organisms they must originally have been added in the milking or afterward and the milk is abnormal whether these germs are the result of heavy contamination at the source or have developed from a slight contamination because the milk has been kept at high temperatures or because the milk is so old or stale that they have had time to grow in it. It is the duty of those regulating the supply to see that milk as near

normal as possible is marketed. When the sources of milk supply are near at hand and adequate refrigeration is available, the counts that represent sanitary production and commendable handling in transit will be lower than when the sources of supply are hundreds of miles away or when dairymen have to contend with lack of natural ice, lack of cold water and high air temperatures. It might be that part of the milk supply of a city was produced under favorable conditions on farms in the adjacent country and part on equally good farms far away so that question would arise whether any bacterial standard that might be set would not be unjust for the reason that the home dairies could easily attain it, whereas it would be both difficult and expensive for the foreign dairies to do so. As far as the writer is aware such a condition is unusual because home dairies usually hold the market till the high price of farm land, etc., makes dairying unprofitable. However, should there actually be cases like this suppositious one, it should not be difficult to establish a standard that will expose neither set of dairymen to unfair competition. The outsider invades the local market, as a rule, because he is in a region of cheap production. It is only fair that he be held to local standards even if it is slightly more expensive for him to meet them than for the native to do so.

It is asserted that since milk is consumed long before its bacterial count is known, bacteriological standards condemn the dairy and not the milk and that they therefore fail of their object. If it be admitted that the intent of bacteriological examinations is to keep specific batches of suspected milk from being consumed by the public, they certainly do fail, but if it is considered that their object is to prevent the habitual consumption of milk of high bacterial content, they may be credited with considerable success on the testimony of the dealers in such milk who, as a rule, are the ones who protest most vehemently against the publication of bacterial counts.

As to the contention that bacteriological examinations leave much to be desired, in that they fail to distinguish between animal contamination which very rarely is the source of the acute infections in man, and human contamination which often causes them, it must be admitted there is much truth. Still, the importance of this defect is considerably lessened by the fact that bovine tuberculosis may be transmitted to milk in the dung or directly from the udder and that septic sore throat though primarily of human origin in most of the widespread epidemics of the disease has been traced to udder infection and that certain animal diseases that afflict man less commonly than these are conveyed in animal secretions and excretions.

Some disapprove of bacterial standards because of the difficulty of enforcing them. Certainly any who contemplate establishing standards will do well to consider this point. In cases brought to jury trial it is

often hard to get convictions because it is difficult to present the subject of bacterial contamination of milk to jurors in an intelligible way. They understand the significance of skimming, watering and of the addition of preservatives but bacteria are rather beyond them and they are inclined to think that in selling milk of a prescribed bacterial count the milk dealer has been guilty of violating a technical provision of the code of little importance and accordingly to deal leniently with him. Moreover, cases brought against dealers for violation of the bacterial standard are apt to be expensive to try for they offer plenty of opportunity for the introduction of expert testimony. Besides, although decisions have been rendered that uphold bacterial standards some health officials doubt whether the highest courts would sustain them and are loth to make the test. The net result is that, although many cities have bacterial standards, the number of cases that are brought for violating them are few, although milk that contains bacteria in excess of the standards is often sold. One reason for this, apart from any question as to the legality or illegality of the standard, is that it is considered better policy to call the attention of dealers to the fact that their milk violates the standard, in the hope that they will find the cause and bring down the count, than it is to prosecute freely.

The question may then be asked, of what value are bacterial standards? They are useful in that the public sooner or later begins to demand milk that complies with the standards and then the dealers begin to furnish it. To do this they have to improve in their methods of doing business and it results that boards of health and other agencies take part in educating dairymen, contractors and consumers as to how milk should be produced and cared for, with the result that better milk is marketed.

**Significance of Predominance of Acid-forming and of Putrefactive Bacteria.**—The better laboratories supplement the bacterial count with other tests that are designed to show the relative number of lactic, gas-forming and putrefactive bacteria in the milk and from these determinations make certain tentative conclusions. Milks showing a high percentage of lactic organisms suggest that the milk may have been produced under cleanly conditions but that there has been time for these organisms to grow, or that possibly the utensils are not kept clean and sterile. Large numbers of gas-forming and putrefactive bacteria are indicative of dirty methods. Similarly, other tests are used and deductions made from them. Such tests often enable inspectors to economize time by indicating the probable source of trouble that they are sent out to help some farmer find and eliminate.

**Significance of the Streptococci.**—Besides using the bacterial count in controlling the milk supply it has been proposed to use other bacteriological tests as a basis for excluding milk from the market.

In many laboratories the presence in milk of streptococci forming chains in lactose broth at 98.6°F. is accepted as evidence that the milk or a part of it was from infected udders and some hold that it proves the milk polluted with cow dung. Rogers, Clark and Evans have investigated the validity of the test. They studied 51 cultures from two herds in which infected udders had given trouble and found that the cultures could be divided into two varieties which were related but which were separated by certain distinctive characters. Nearly all cultures of both types fermented lactose, saccharose and dextrose and failed to ferment raffinose, starch and inulin but the more numerous type which had a marked tendency to form long chains in broth at 98.6°F. failed to ferment mannit and glycerine and to liquefy gelatin, whereas the other type nearly always did so. The type with the tendency to form long chains corresponds to *St. pyogenes* as regards the reactions that have been considered. A study of 114 cultures of streptococci isolated from bovine feces showed they differed from the long-chain type in the amount of acid produced and in the substances fermented, for besides fermenting dextrose, saccharose and lactose, they almost always fermented raffinose, while about 50 per cent. of them fermented starch and a few inulin but they were unable to utilize the alcohols except that a few fermented mannit. From this work and the study of 42 cultures isolated from milk from 25 farms by inoculating lactose bile, incubating at 98.6°F. and plating only those tubes showing distinct chains, the authors make the statement that, while their results are not conclusive, they hold them as substantiating the belief that the presence in lactose bile, inoculated with milk and incubated at 98.6°F., of chain-forming streptococci is good presumptive evidence of milk from infected udders. They point out, however, that udders may contain streptococci of the pyogenes type without showing physical signs of infection.

**Significance of B. coli.**—In water analysis the presence of the colon bacillus is regarded as indicative of fecal pollution because the organism is a normal inhabitant of the intestines of man and of the lower animals and for the same reason some health departments have endeavored to make the presence of excessive numbers of these bacteria in milk a reason for excluding it from the market. This has excited vigorous protest on the grounds that these germs multiply rapidly in milk which they do not in water, and that the studies of Prescott and others show that organisms of the colon group are found not only in feces but also on grains which are commonly used as cattle feed.

The feasibility of using this test has been investigated by Rogers, Clark and Evans. They began their investigation with a study of 120 cultures from milk samples taken in various parts of the country. It was found possible to divide these cultures into two groups on the basis

of the ratio of carbon dioxid to hydrogen in the gas produced in the fermentative reactions that were studied. One of these two groups had a carbon dioxid ratio of 1:1 and was designated as the low-ratio group. The other group had a higher ratio. The correlation of other characters with these types of gas ratio was sufficiently marked to make the separation of the two groups clear and distinct. To determine whether both groups were normal inhabitants of the intestine a study was made of 150 cultures from bovine feces. It was found that 149 of them gave the 1:1 ratio which characterized about 50 per cent. of the 120 milk cultures. The single, high-ratio culture was distinguished by a yellow pigment. The fermentative reactions that were studied confirmed the agreement between the feces organisms and the low-ratio milk cultures. Further studies showed that the entire low-ratio group is divided into two subgroups corresponding to *B. coli communis* and *B. coli communior.* To determine whether the colon bacillus occurs elsewhere than in the intestine a study was made of 166 cultures from 33 samples of common grains. Nearly all of these cultures responded to presumptive tests for *B. coli* and many would have passed the usual confirmatory tests. On the basis of gas ratio the grain cultures were separable into three groups, viz.: (1) eight of the cultures had the characteristic colon ratio; (2) a group that produced only carbon dioxid and so had a ratio equal to infinity; (3) a group that gave gas ratios varying from 1.90 to 2.90. In the 166 cultures a number of pigment formers were noticed and so the cultures were matched with Ridgeway's standard color plates whereby it was demonstrated that a larger proportion of the cultures formed pigment to some extent. However, the amount was so small in most cases that the culture would not ordinarily be considered pigmented. Among the decidedly colored cultures were all those that gave the colon ratio of 1:1. In all cases the color varied from a cadmium yellow to cream color or nearly white. The 153 cultures that gave a high ratio were divided by the authors into five groups.

Therefore, the entire collection was divided into six groups; one of them included 40 cultures and another 90, and in these the uniformity of reaction was striking. The number of cultures in the other groups was so small as to make the groups little more than suggestions.

The authors conclude that the bacteria of the colon type occurring in market milk may be divided into two distinct groups one of which is characterized by a low carbon dioxid ratio that is typical of the colon bacillus of the bovine intestine. The other, or high-ratio group, is numerous in milk but occurs only rarely in the bovine intestine. The surface of dried grains is the source of a number of types of colon but only one of them resembles the low-ratio feces type and this one is distinguished by its ability to form pigment. Of the cultures from grains the type that is most common probably corresponds to *Bact. lactis*



149 = 1:1 + yellow pig.

*aerogenes.* However, many grain cultures would answer to the usual tests for *B. coli communis* and *B. coli communior.*

While the presence of fecal bacteria in milk may be determined with great certainty the ordinary presumptive tests and even the usual confirmatory ones do not necessarily prove the contamination of milk with fecal matter.

**Significance of B. welchii.**—Savage has pointed out that the spores of *B. welchii* are present in cow dung in considerable numbers and has suggested that since the organism does not multiply in milk it might be used as an index of animal contamination of market milk. However, he mentions the fact that it is not known how far the organism may gain entrance to the milk from other sources than manure.

**Bacterial Tests of Pasteurized Milk.**—In the examination of pasteurized milk, bacteriological tests are considered of great value. They are used to test the sterility of the apparatus before starting a run and by taking samples of the milk at different stages of its journey through the machines to determine the places where defects occur. The finished product should meet reasonable bacteriological standards, if the pasteurization has been successful. In some cities a certain percentage reduction in bacteria is required. The fallacy in this standard has been pointed out in the chapter on pasteurization. The best way is to forbid the pasteurization of milk that has a bacterial content in excess of a stated amount and to require that the pasteurized milk shall not contain over a stated number of bacteria per cubic centimeter.

In some cities the colon test is used as an index of the efficiency of pasteurization. Of this Ayers and Johnson say that it is complicated by the ability of certain strains to survive a temperature of 145°F. for 30 min. and to develop rapidly when pasteurized milk is held under temperature conditions that might be met during storage and delivery. The presence of a large number of colon bacilli right after the heating process may indicate improper treatment of the milk. Milk pasteurized at 150°F. or above for 30 min., according to the researches of these authors, would not contain colon bacilli but they emphasize the fact that more extensive work might reveal strains of colon bacilli that would survive this and even higher temperatures.

**Prevention of Milk-borne Epidemics.**—Besides keeping up the sanitary condition of places where milk is produced, handled and sold, by inspecting and scouring them, and besides maintaining the quality of the supply by laboratory work, it is necessary to make a systematic effort to protect the milk from infection and to prevent it becoming the vehicle of contagion. This work usually receives the personal attention of the health officer. In the larger cities a staff of specially trained men deals with communicable diseases and usually coöperates with the bureau of milk inspection in carrying on that part of the work which pertains to

the milk supply. In the smaller cities the health officer and members of the milk inspection service do it all.

The work is naturally divided into two parts: that which is done in the country districts, usually within the sphere of authority of some other official, perhaps a county health officer; and that which is carried on in the city where the municipal health officer has sole jurisdiction. The first step is to see that all cases of infectious disease of men and animals are promptly reported. As regards the latter, veterinarians usually willingly give helpful service, and coöperation in handling the cases is generally mutually advantageous. The reporting of cases of human contagion on the dairy farms and among the patrons and employees of the creameries, country and city milk plants, etc., should be incumbent on the dairymen and contractors who sell their milk or own the factories. Besides, arrangements should be made with the local physicians and health officer to report all cases of infection in the dairy district and with the registrar, to report all deaths from contagion. It is for the municipal health officer to see that all cases of communicable disease in the city are promptly reported and that in each report the name of the milk dealer is given.

For collecting and recording this and other data relating to communicable diseases suitable blanks and a system of office records should be devised. All cases of contagion should be spotted on a large map of the city. This gives a general view of the amount of infection and shows the relative prevalence of the several diseases. Oftentimes, too, the groupings of the cases on the map are suggestive of epidemiological relationships. Thus, if the spots are scattered in all parts of the city where the public water supply is used, the suspicion is aroused that the water is infected and this seems more certain if no spots appear in a section of the city not served by the public supply. A row of spots along a line of sewer pipe may indicate that it is leaky and is polluting the wells in the street in which it is laid. Sometimes the spots may be disposed about a well in such a way that near it, they may be close together but further away spread apart and at a greater distance disappear. A circle of short radius and with the well as a center will circumscribe all the cases which denotes that the neighborhood is using the water of an infected well. If the spots mark out the delivery route of a milk dealer, the probability is that his milk is infected. In the case of an infected route that is generally patronized the spots may be so broadly scattered that doubt is cast on the purity of the public water supply but careful inquiry will dispel it. Other groupings have their proper interpretations. Also, the city should be divided into several fairly large districts which should be kept intact from year to year and the occurrence of cases of contagion in them should be noted for careful study. Thus, the cases of contagion should be recorded as they occur week by week throughout the year over a series

of years and from this should be figured the average number, or the normal incidence of cases, in each district in each of the 52 weeks so that at any time that may be necessary it may be quickly told whether there are more cases than normal for that week.

Each case of infection, as it occurs, should be charged to the dealer who happens to be serving the patient with milk. This should be done not with the idea of fixing the responsibility for the case on the dealer but rather to discover the occurrence of any unusual number of cases among the dealer's customers. If the number of cases appears to be excessive, care should be taken to ascertain whether it really is so, by figuring whether the proportion of all the cases in the city that he is getting corresponds to the size of his milk route or not.

In some cities dairymen are required to file lists of their customers with the board of health at stated intervals. This gives information as to the size and location of the route and is sometimes convenient in checking up statements of patients as to the milk they were using when they were stricken with disease.

It is highly important to be able to trace milk back to the producer with celerity and certainty. So there must be some way of recording the point of origin of each shipment of milk. In New York City the Department of Health requires that to each can of milk there be attached a tag showing where the milk was shipped from and the date of shipment. The milk companies are also required to keep a record of the distribution of this milk to the various retailers. Bottled milk must be dated and be marked with the name of the creamery or bottling plant and the records of the companies must show on what wagons and routes milk bottled in the country is distributed. Retail dealers are required to keep the can tags for 60 days.

It is important to have some routine way of notifying the dairyman of the occurrence of cases of contagion on his route, otherwise he is likely to violate the provisions of the code relative to taking away bottles from infected homes. Epidemics have been caused in this way. If bottles are left daily at infected premises and not taken away until the case is over, a considerable number accumulate and there is some possibility of their infecting the dairy or of their being put into circulation without proper sterilization. The danger is greatest when the dairyman is not very intelligent and when, as is often the case in small cities, he lacks facilities for sterilizing. In such cases the board of health should sterilize the bottles with bleaching powder before they are taken from the premises.

There is a further point to be considered in controlling the spread of contagious disease through milk and it is pertinent to other phases of milk regulation as well. It is, as to how to prevent milk that is excluded from one town finding market in another. That this often happens there is no doubt. Sometimes it can be prevented by notifying a State depart-

ment of milk control of the exclusion but often there is no such board with authority or the resources to prevent the shipment of the milk. Generally the best plan of protection is for neighboring communities to adopt an arrangement for promptly notifying each other of the exclusion of any dairy from one of the cities. Some go further and exchange their weekly reports upon communicable disease.

**Methods of Maintaining Public Interest in the Milk Supply.**—These are the principal lines along which efforts at milk control are directed. There remain to be considered means of maintaining interest in the milk situation and of making the milk inspection bureau serviceable to the community. Carefully considered and well-directed publicity is the agent for accomplishing these things. Newspapers generally gladly assist temperate constructive campaigns for improving the milk supply. The rural press will usually accept short articles on such subjects as cow-testing associations, bull associations, the handling of manure, feeding, the production of clean milk and the like. Often country and city papers will publish dairy scores. In a community where control work is new it is well to begin with publishing only the good scores. This excites the interest of the farmers and is an incentive to those whose places are in poor condition to improve them. Ultimately the scores of all the farms can be published. The question of whether chemical and bacteriological milk analyses should be published and the supplies of all the dealers rated has excited discussion. The first question that presents itself is whether the publication of analyses is legal; in communities where it is not, the matter is ended. Those who oppose publishing analyses contend that to do so is unfair to the dealer because the consumers are unable to understand them and so are confused and often misled by them. Those who would publish analyses feel that the public pays for all the analytical work and so is entitled to know how the different supplies may be judged in accordance with it. Montclair, N. J., and other cities have long published both the chemical and bacteriological analyses of the milk of all the dealers in their annual reports. This by many is considered fair because it shows the general character of the supplies over a considerable period of time. Others regard this as stale news and believe that few consumers use it. This latter criticism certainly is not valid in Montclair. In some cities the analyses are published in the daily press right after they are made. The objection to this is that an opinion in regard to a milk supply should never be formed on a single analysis and that in the best-managed dairies accidents will happen that might cause an occasional analysis to misrepresent completely the real character of the supply. It is truly held that the regular publication of analyses makes it unnecessary to adopt a bacterial standard because dealers will strive to get lower counts than their competitors and so milks with high counts will gradually decrease in number and the average maxi-

mum count grow lower. The tendency of consumers to select milk with low counts acts in the same way. Many believe that the publication of analyses makes the marketing of good milk profitable. Some take the rather doubtful ground that the board has done its duty when it makes known the quality of the various milks on the market and that it is then

FIG. 63.—Bacteria in the same quantity of milk from different sources.

Fig. 1.—Exceptionally pure milk.
Fig. 2.—Blauvelt, Geo. M. Canfield, Fairfield certified.
Fig. 3.—Hamilton, Fairfield Nursery, Van Reyper.
Fig. 4.—Puritan Dairy, Offhouse.
Fig. 5.—Croot, Borden M. H. Canfield, O' Dowd.
Fig. 6.—Dirty milk.

*(From the 14th. Annual Report of the Board of Health of the Town of Montclair, N. J.)*

the public's own fault if it uses the inferior ones. Others feel that it is the duty of the board to protect the public from the folly of choosing the poorer milks. Many argue that the publication of scores and analyses is an ineffective way of getting good results, that these should be employed to the benefit of the public and dealers by using them in grading the milk. This seems to be the opinion of the Committee of the International Milk

Dealers' Association on the Improvement of Milk Supplies for it recommends that milk dealers urge upon boards of health in their respective cities the establishment and supervision of grades of milk and it advises the adoption, with such modifications as local conditions may suggest, of the grades defined by the Commission appointed by the New York Milk Committee. Pending the establishment of grades of milk the Committee of the Milk Dealers' Association advises that dealers urge upon boards of health the publication of both chemical and bacteriological analyses or the publication of the scores of the various supplies distributed, as in effect in Seattle.

In these Seattle classified milk scores 100 points are allowed for the dairy farm, 100 for chemical analysis, and 100 for bacteriological analysis, making a total of 300 possible in the perfect score, and the percentage that the total number of points actually scored is of the total possible score gives the final rating. The dairy farm is scored according to the "official" score card. The chemical and bacteriological analyses are scored in accordance with values assigned on the U. S. Department of Agriculture score card for milk.

So, if a milk was produced on a farm that was scored 59 points and if the chemical analysis showed that it contained 12.89 total solids entitling it to 90 points and if its bacterial count was 84,000 giving it 60 points, its final rating would be the sum of these points or 209 divided by 300 or 69.6 per cent.

A more highly elaborated system of rating was devised by Woodward for use in Washington, D. C.

The interest of producers, milk-plant managers and dealers is stimulated by calling meetings at which opportunity is given them to discuss their difficulties and to make suggestions with regard to the administration of the milk code. It is particularly important in drawing up a new code or in amending an old one that these men be called into consultation. Their intimate knowledge of the local situation and their practical experience, if availed of, will prevent the incorporation of unworkable provisions into the law and the adoption of a code so far beyond the ability of the industry to live up to that it will be a failure from the date of its enactment. Besides this, the spirit of fair play demands that the men whose business is to be regulated should have ample opportunity to present objections and suggestions in regard to the proposed legislation. Too often half-informed committees and legislative bodies have imposed impossible laws on the dairy business to the detriment of all concerned.

The good will and support of the producers can be won by helping them to establish cow-testing associations, bull associations and other things calculated to advance their prosperity.

The effort should be made to develop the habit of reading and study in the dairymen. To this end the bulletins of the various experiment

stations and of the Federal Government should be distributed among them and a loan library of such literature as cannot be given away should be kept in the department.

One of the problems that the bureau of control has to meet is how to make the community as a whole respond to its work. Unless the citizens can be interested in the milk question and be made participants in the movement to improve the milk supply and unless they can be made to feel that they are being benefited in a practical way, no lasting results can be obtained. Therefore, the effort must be made to carry the work to the public. Usually there is opportunity to do this through the medium of lectures before women's clubs, granges, fraternal orders and church societies. In some cases the public schools can be induced to give some instruction on milk. If there is a domestic science department in the high school, its head is usually very glad to utilize material furnished by the control bureau and may even arrange trips to dairies and milk plants.

**UNITED STATES DEPARTMENT OF AGRICULTURE**

**Bureau of Animal Industry**

Dairy Division

**SCORE CARD FOR MILK**

(Front)

*Place*..................................................................

*Class*.................................... *Exhibit No*..........................

| Item | Perfect score | Score allowed | Remarks |
|---|---|---|---|
| Bacteria.................. | 35 | ......... | Bacteria found per cubic centimeter ............. |
| Flavor and odor.......... | 25 | ......... | Cowy, Bitter, Feed, Flat, Strong, ............. |
| Visible dirt.............. | 10 | ......... | ...................................... |
| Fat...................... | 10 | ......... | Per cent. found.................... |
| Solids-not-fat............ | 10 | ......... | Per cent. found.................... |
| Acidity.................. | 5 | ......... | Per cent. found.................... |
| Bottle and cap........... | 5 | ......... | Cap..............................<br>Bottle.......................... |
| Total.................. | 100 | ......... | |

*Exhibitor*..............................................................

*Address*...............................................................

(*Signed*)..........................................................

*Judge.*

*Date*......................................, 191

Sometimes it is possible to set up a milk booth at some local bazaar or even to organize a milk show at which lectures are given, lantern slides or moving pictures of the local dairies are exhibited and perhaps a milk and cream contest, with prizes for the best milk, is staged. The object of these contests is twofold. First, the dairymen who enter the contest learn a great deal in a practical way about sanitary milk production and this lesson is never unlearned. Besides, the success of the prize winners whets the ambition of others so that they bestir themselves to do better. Second, the public is always interested in a contest and a successfully managed competition always excites lively discussion of all phases of the milk question. The judges should be selected with care and the milk and cream should be scored on the cards of the U. S. Department of Agriculture, facsimiles of which appear on pages 456, 457 and 458.

## SCORE CARD FOR MILK
(Back)

## DIRECTIONS FOR SCORING

**Bacteria per Cubic Centimeter—Perfect Score, 35**

| | Points | | Points |
|---|---|---|---|
| Under 500 | 35.0 | 25,001– 30,000 | 29.0 |
| 500– 1,000 | 34.9 | 30,001– 35,000 | 28.0 |
| 1,001– 1,500 | 34.8 | 35,001– 40,000 | 27.0 |
| 1,501– 2,000 | 34.7 | 40,001– 45,000 | 26.0 |
| 2,001– 2,500 | 34.6 | 45,001– 50,000 | 25.0 |
| 2,501– 3,000 | 34.5 | 50,001– 55,000 | 24.0 |
| 3,001– 3,500 | 34.4 | 55,001– 60,000 | 23.0 |
| 3,501– 4,000 | 34.3 | 60,001– 65,000 | 22.0 |
| 4,001– 5,000 | 34.0 | 65,001– 70,000 | 21.0 |
| 5,001– 6,000 | 33.8 | 70,001– 75,000 | 20.0 |
| 6,001– 7,000 | 33.6 | 75,001– 80,000 | 19.0 |
| 7,001– 8,000 | 33.4 | 80,001– 85,000 | 18.0 |
| 8,001– 9,000 | 33.2 | 85,001– 90,000 | 17.0 |
| 9,001–10,000 | 33.0 | 90,001– 95,000 | 16.0 |
| 10,001–11,000 | 32.8 | 95,001–100,000 | 15.0 |
| 11,001–12,000 | 32.6 | 100,001–120,000 | 12.5 |
| 12,001–13,000 | 32.4 | 120,001–140,000 | 10.0 |
| 13,001–14,000 | 32.2 | 140,001–160,000 | 7.5 |
| 14,001–15,000 | 32.0 | 160,001–180,000 | 5.0 |
| 15,001–20,000 | 31.0 | 180,001–200,000 | 2.5 |
| 20,001–25,000 | 30.0 | Above 200,000 | 0.0 |

NOTE.—When the number of bacteria per cubic centimeter exceeds the local legal limit the score shall be 0.

**Flavor and Odor—Perfect Score, 25**

Deductions for disagreeable or foreign odor or flavor should be made according to conditions found. When possible to recognize the cause of the difficulty it should be described under Remarks.

### Visible Dirt—Perfect Score, 10

Examination for visible dirt should be made only after the milk has stood for some time undisturbed in any way. Raise the bottle carefully in its natural, upright position, without tipping, until higher than the head. Observe the bottom of the milk with the naked eye or by the aid of a reading glass. The presence of the slightest movable speck makes a perfect score impossible. Further deductions should be made according to the amount of dirt found. When possible the nature of the dirt should be described under Remarks.

### Fat in Milk—Perfect Score, 10

| | Points | | Points |
|---|---|---|---|
| 4.0 per cent. and over | 10.0 | 3.2 per cent | 6 |
| 3.9 per cent | 9.8 | 3.1 per cent | 5 |
| 3.8 per cent | 9.6 | 3.0 per cent | 4 |
| 3.7 per cent | 9.4 | 2.9 per cent | 3 |
| 3.6 per cent | 9.2 | 2.8 per cent | 2 |
| 3.5 per cent | 9.0 | 2.7 per cent | 1 |
| 3.4 per cent | 8.0 | Less than 2.7 per cent | 0 |
| 3.3 per cent | 7.0 | | |

NOTE.—When the per cent. of fat is less than the local legal limit the score shall be 0.

### Solids-not-Fat—Perfect Score, 10

| | Points | | Points |
|---|---|---|---|
| 8.7 per cent. and over | 10 | 8.1 per cent | 4 |
| 8.6 per cent | 9 | 8.0 per cent | 3 |
| 8.5 per cent | 8 | 7.9 per cent | 2 |
| 8.4 per cent | 7 | 7.8 per cent | 1 |
| 8.3 per cent | 6 | Less than 7.8 per cent | 0 |
| 8.2 per cent | 5 | | |

NOTE.—When the per cent. of solids-not-fat is less than the local legal limit the score card shall be 0.

### Acidity—Perfect Score, 5

| | Points | | Points |
|---|---|---|---|
| 0.2 per cent. and less | 5 | 0.23 per cent | 2 |
| 0.21 per cent | 4 | 0.24 per cent | 1 |
| 0.22 per cent | 3 | Over 0.24 per cent | 0 |

### Bottle and Cap—Perfect Score, 5

Bottles should be made of clear glass and free from attached metal parts. Caps should be sealed in their place with hot paraffin, or both cap and top of bottle covered with parchment paper or other protection against water and dirt. Deduct for tinted glass, attached metal parts, unprotected or leaky caps, partially filled bottles, or other conditions permitting contamination of milk or detracting from the appearance of the package.

UNITED STATES DEPARTMENT OF AGRICULTURE

Bureau of Animal Industry

Dairy Division

SCORE CARD FOR CREAM

*Place*..........................................................................

*Class*.............................. *Exhibit No*...................

| Item | Perfect score | Score allowed | Remarks |
|---|---|---|---|
| Bacteria.................. | 35 | ......... | Bacteria found per cubic centimeter ............. |
| Flavor and odor.......... | 25 | ......... | Cowy, Bitter, Feed, Flat, Strong, ............. |
| Visible dirt.............. | 10 | ......... | ................................ |
| Fat..................... | 20 | ......... | Per cent. found.................... |
| Acidity.................. | 5 | ......... | Per cent. found.................... |
| Bottle and cap........... | 5 | ......... | Cap.............................. Bottle........................... |
| Total.................. | 100 | ......... | |

*Exhibitor* ......................................................................

*Address* ......................................................................

(*Signed*) ............................................................

*Judge.*

*Date* ........................., 191

The directions for scoring are the same as for milk.

**Measures of Success in Controlling the Milk Supply.**—The success of the effort to control the production and sale of milk is measured in three ways, namely: (1) by the decrease in infant mortality; (2) by the increase in the consumption of milk; and (3) by the prosperity of the dairy business.

**Infant Mortality and the Milk Supply.**—Undoubtedly the belief of the medical profession that contaminated milk was largely responsible for the high infant mortality of the summer months started the first comprehensive campaigns to improve milk supplies. In the seventies there was believed to be a direct causal relationship between the high air temperatures and the increased death rate of children in summer, but with the development of bacteriology less importance came to be attached to the effect of heat *per se* and much more to infections caused by slightly spoiled foods. When health departments began to publish the results

of their bacteriological examinations of milk the coincidence between the high bacterial counts of summer and the high total infant mortality of that season was noted and further analysis showed that the high death rate of infants from intestinal disease and these high counts also corresponded. So, it was concluded that dirty milk was one of the causes of this sort of trouble in babies.

To determine the injurious effect of bacteria in milk on infants more exactly and if possible to discover what bacteria were the harmful ones, Park and Holt from 1901 to 1904 made an extensive study of the problem in certain hospitals and tenement districts of New York City. Their conclusions in part are:

"1. During cool weather neither the mortality nor the health of the infants observed in the investigation was appreciably affected by the quality of the market milk or by the number of bacteria which it contained.

"2. During hot weather, when the resistance of the children was lowered, the kind of milk taken influenced both the amount of illness and the mortality; those who took condensed milk and cheap store milk did the worst, and those who received breast milk, pure bottled milk and modified milk did the best. The effect of bacterial contamination was very marked when the milk was taken without previous heating; but, unless the contamination was very excessive, only slight when heating was employed shortly before feeding.

"3. The number of bacteria which may accumulate before milk becomes noticeably harmful to the average infant in summer differs with the nature of the bacteria present, the age of the milk, and the temperature at which it has been kept. When milk is taken raw, the fewer the bacteria present the better are the results. Of the usual varieties, over 1,000,000 bacteria per cubic centimeter are certainly deleterious to the average infant. However, many infants take such milk without apparently harmful results. Heat of 145°F. for 30 min. or of 170°F. for a shorter period not only destroys most of the bacteria present, but apparently some of their poisonous products. No harm from the bacteria previously existing in recently heated milk was noticed in these observations unless they had amounted to many millions, but in such numbers they were decidedly deleterious.

"4. When milk of average quality was fed, sterilized and raw, those infants who had received milk previously heated did, on the average, much better in warm weather than those who received it raw. The difference was so quickly manifest and so marked that there could be no mistaking of the results.

"5. No special varieties of bacteria were found in unheated milk which seemed to have any special importance in relation to the summer diarrheas of children. A few cases of acute indigestion were seen immediately following the use of pasteurized milk more than 36 hr. old. Samples of such milk were found to contain more than 1,000,000 bacteria per cubic centimeter, mostly spore-bearing varieties. The deleterious effects, though striking, were neither serious nor lasting.

"6. After the first 12 months of life infants are less and less affected by the bacteria in milk derived from healthy cattle and the air. According to these

observations, when milk had been kept cool, the bacteria did not appear to injure the children over 3 years of age at any season of the year, unless in very great excess.

"7. While it is true that even in tenements the results with the best bottle feeding are nearly as good as average breast feeding, it is also true that most of the bottle feeding is at present very badly done; so that, as a rule, the immense superiority of breast feeding obtains."

As a whole these extensive studies showed a less definite relationship between dirty milk and infant mortality than previously had been believed to exist and they encouraged many other investigations of this question in this country, a few of which may be noted.

It has long been claimed that the infant mortality was lower among breast-fed than among bottle-fed babies. The statement has been made that 80 to 85 per cent. of all infant deaths occur among bottle-fed babies but even if this is true it does not necessarily indicate that the percentage of deaths among bottle-fed infants is excessive for if it should be true also, that 80 per cent. of all infants are bottle-fed, this percentage of infants' deaths is what would be expected and so is not an arraignment of bottle feeding. Davis has reported the results of a study by the Boston City Board of Health to determine the percentage of babies that are bottle-fed and has made some deductions therefrom as to the influence of bottle feeding on infant mortality. The work is based on the replies to a circular letter of inquiry and on supplementary information obtained by board of health nurses. In all there were 736 replies. Table 118 shows the nativity of the mother and the number of living babies at various age periods from 2 weeks to 1 year old that were breast- or bottle-fed and it also shows, by the addition of the deaths occurring within the year at the several age periods, the total number of breast- and bottle-fed babies and the percentages, corrected by these deaths, for the various age periods. Table 119 shows the mortality of infants in the City of Boston in 1911, by age, nativity of mother and by feeding. Table 120 shows the mortality of infants in the City of Boston in 1911, by month, age and feeding. In this table the slight increase of deaths among breast-fed babies during the summer months is strikingly contrasted with the multifold increase in deaths among bottle-fed babies in July, August and September. Table 121 is a comparison of the actual infant death rates and estimated infant death rates, had all babies been breast-fed.

"The conclusions that may be reached from the figures in this last table are startling. For instance, had all the infants above 2 weeks of age been breast-fed or equally well-fed, for there is reason to believe that bottle feeding may be so safeguarded that it will be productive of no greater infant mortality than breast feeding, there would have been but 1,253 infant deaths, whereas had all been bottle-fed there would have been 4,352 deaths. The actual number of infant deaths in 1911 was 2,245, giving an infant death rate of 127 per 1,000 births but

TABLE 118.—THE NUMBER OF BREAST-FED AND BOTTLE-FED BABIES AMONG 736 LIVING BABIES 2 WEEKS TO 1 YEAR OLD AND AMONG 152 BABIES THAT DIED IN THE FIRST YEAR OF LIFE, MAKING IN ALL A STUDY OF 888 BABIES

| Nativity of mother | 2 weeks to 1 year | 2 weeks to 1 year | | 2 weeks to 1 month | | 1 to 3 months | | 3 to 6 months | | 6 to 9 months | | 9 to 12 months | | Percentage of breast-fed | Corrected percentage of breast-fed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Breast | Bottle | Breast | Bottle | Breast | Bottle | Breast | Bottle | Breast | Bottle | Breast | Bottle | | |
| United States | 272 | 174 | 98 | 44 | 8 | 33 | 23 | 42 | 19 | 24 | 29 | 31 | 19 | 64 | 59 |
| Ireland | 120 | 93 | 27 | 17 | 1 | 24 | 6 | 23 | 8 | 16 | 55 | 13 | 7 | 77 | 71 |
| England, Scotland and Wales | 20 | 15 | 5 | 1 | ... | 3 | 1 | 4 | 1 | 3 | 2 | 4 | 1 | ... | ... |
| Germany | 2 | 1 | 1 | ... | ... | ... | ... | 1 | 1 | ... | ... | ... | ... | ... | ... |
| Canada | 69 | 38 | 31 | 5 | 11 | 8 | 7 | 8 | 99 | 8 | 8 | 9 | 6 | 55 | 51 |
| Scandinavia | 10 | 8 | 2 | 1 | ... | 1 | 1 | 2 | ... | 3 | 1 | 1 | ... | ... | ... |
| Italy | 123 | 106 | 17 | 24 | 2 | 23 | 4 | 23 | 2 | 18 | 2 | 18 | 7 | 86 | 83 |
| Russia and Poland | 120 | 98 | 22 | 20 | 2 | 21 | 7 | 21 | 6 | 17 | 6 | 19 | 1 | 82 | 79 |
| Totals | 736 | 533 | 203 | 112 | 14 | 113 | 49 | 124 | 46 | 89 | 53 | 95 | 41 | 72 | ... |
| Percentages | ... | 72 | 28 | 89 | 11 | 70 | 30 | 73 | 27 | 63 | 37 | 70 | 30 | ... | ... |
| Total death additions necessary to obtain corrected percentages of breast- and bottle-fed babies | 152 | 20 | 56 | 3 | 6 | 5 | 16 | 5 | 15 | 4 | 11 | 3 | 8 | ... | ... |
| Corrected percentages | ... | 68 | 32 | 85 | 15 | 64 | 36 | 68 | 32 | 59 | 41 | 67 | 33 | ... | ... |

TABLE 119.—MORTALITY OF INFANTS IN BOSTON, MASS., IN 1911, BY AGE, NATIVITY OF THE MOTHER AND FEEDING (FOR INFANTS OVER 2 WEEKS OF AGE) (DAVIS)

| Nativity of mother | Total deaths under 2 years | 2 weeks to 1 year | | Total deaths 2 weeks to 1 month | | 1 to 3 months | | 3 to 6 months | | 6 to 9 months | | 9 to 12 months | | Percentage of deaths 2 weeks to 1 year, breast-fed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Breast | Bottle | Breast | Bottle | Breast | Bottle | Breast | Bottle | Breast | Bottle | Breast | Bottle | |
| United States | 924 | 106 | 544 | 26 | 58 | 20 | 172 | 31 | 144 | 15 | 93 | 14 | 77 | 16 |
| Ireland | 345 | 48 | 179 | 7 | 20 | 16 | 47 | 8 | 53 | 8 | 29 | 9 | 30 | 21 |
| England, Scotland and Wales | 61 | 13 | 25 | 1 | 2 | 4 | 6 | 5 | 10 | 1 | 4 | 2 | 3 | 34 |
| Germany | 12 | 3 | 6 | 1 | .... | ... | 2 | ... | 1 | 1 | ... | 1 | 3 | 33 |
| Canada | 232 | 32 | 128 | 5 | 10 | 7 | 40 | 7 | 33 | 7 | 35 | 6 | 10 | 20 |
| Scandinavia | 30 | 5 | 15 | .... | 3 | 2 | 4 | 3 | 4 | ... | 3 | ... | 1 | 25 |
| Italy | 292 | 124 | 112 | 13 | 13 | 26 | 21 | 21 | 27 | 37 | 32 | 27 | 19 | 53 |
| Russia and Poland | 230 | 60 | 101 | 11 | 8 | 17 | 21 | 11 | 29 | 13 | 23 | 8 | 20 | 37 |
| Other countries | 87 | 21 | 51 | .... | 1 | 6 | 12 | 5 | 10 | 6 | 18 | 4 | 10 | 29 |
| Unknown | 29 | 1 | 25 | .... | 1 | ... | 13 | 1 | 3 | ... | 3 | ... | 5 | 4 |
| Totals | 2,245 | 413 | 1,183 | 34 | 116 | 98 | 338 | 92 | 314 | 88 | 240 | 71 | 178 | 26 |
| Percentages | .... | 26 | 74 | 36 | 64 | 22 | 78 | 23 | 77 | 27 | 73 | 29 | 71 | |

NOTE.—There were four deaths of infants over 2 weeks old where the method of feeding was unknown.

TABLE 120.—MORTALITY OF INFANTS IN BOSTON, MASS., IN 1911, BY MONTH, AGE, AND FEEDING (FOR INFANTS OVER 2 WEEKS OF AGE) (DAVIS)

| Month | Total deaths under 1 year | Total deaths | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 weeks to 1 year | | 2 weeks to 1 month | | 1 to 3 months | | 3 to 6 months | | 6 to 9 months | | 9 to 12 months | |
| | | Breast | Bottle | Breast | Bottle | Breast | Bottle | Breast | Bottle | Breast | Bottle | Breast | Bottle |
| January | 162 | 34 | 64 | 7 | 6 | 10 | 21 | 8 | 20 | 5 | 9 | 4 | 8 |
| February | 175 | 49 | 65 | 8 | 5 | 13 | 17 | 7 | 16 | 13 | 13 | 8 | 14 |
| March | 196 | 41 | 101 | 10 | 8 | 11 | 35 | 7 | 22 | 9 | 27 | 4 | 9 |
| April | 191 | 38 | 102 | 8 | 10 | 9 | 28 | 10 | 23 | 7 | 22 | 4 | 19 |
| May | 181 | 34 | 85 | 7 | 15 | 4 | 22 | 11 | 20 | 5 | 13 | 7 | 15 |
| June | 129 | 21 | 61 | 4 | 8 | 6 | 19 | 3 | 10 | 6 | 14 | 2 | 10 |
| July | 280 | 39 | 184 | 3 | 10 | 8 | 46 | 10 | 46 | 10 | 49 | 8 | 33 |
| August | 260 | 40 | 181 | 5 | 14 | 6 | 40 | 12 | 64 | 8 | 38 | 9 | 25 |
| September | 224 | 40 | 137 | 2 | 16 | 7 | 39 | 10 | 39 | 10 | 23 | 11 | 20 |
| October | 172 | 26 | 86 | 1 | 5 | 9 | 27 | 6 | 28 | 3 | 13 | 7 | 13 |
| November | 138 | 24 | 62 | 3 | 9 | 9 | 24 | 3 | 12 | 5 | 10 | 4 | 7 |
| December | 137 | 27 | 58 | 6 | 10 | 6 | 20 | 5 | 14 | 7 | 9 | 3 | 5 |
| Totals | 2,245 | 413 | 1,186 | 64 | 116 | 98 | 338 | 92 | 314 | 88 | 240 | 71 | 178 |

had all the babies been breast-fed nearly 1,000 babies would have been saved and the death rate instead of being 127 would have been 71, which is comparable to the rate of 62 in New Zealand and to the rate of 61 in South Australia in 1909."

Table 121.—Actual Death Rates and Estimated Death Rates if All Children had been Breast-fed, Boston, Mass. (Davis)

| | Nativity of mother | | | | | |
|---|---|---|---|---|---|---|
| | United States | Ireland | Canada | Italy | Russia and Poland | Totals for Boston |
| Births, 1910 | 6,226 | 2,816 | 1,747 | 2,703 | 2,479 | 17,668 |
| Deaths under 1 year, 1911 | 927 | 345 | 232 | 292 | 230 | 2,245 |
| Rate per 1,000 births (using the 1910 births) | 149 | 123 | 133 | 1 08 | 93 | 127 |
| Percentage of children between 2 weeks and 1 year, breast-fed (estimated) | 59 | 73 | 51 | 83 | 79 | 68 |
| Deaths, 1911, of children between 2 weeks and 1 year | 653 | 227 | 160 | 236 | 162 | 1,603 |
| Percentage of deaths between 2 weeks and 1 year, breast-fed | 16 | 21 | 20 | 53 | 37 | 26 |
| Estimated total infant deaths, 1911, if all above 2 weeks had been breast-fed | 457 | 184 | 135 | 205 | 145 | 1,253 |
| Lives saved if all above age of 2 weeks had been breast-fed | 470 | 161 | 97 | 87 | 85 | 992 |
| Estimated death rate if all above 2 weeks had been breast-fed | 73 | 65 | 77 | 76 | 58 | 71 |
| Estimated reduction in death rate if all above 2 weeks had been breast-fed | 76 | 58 | 56 | 32 | 35 | 56 |

The necessity of carefully analyzing infant mortality statistics before drawing conclusions from them is well illustrated by Dr. Williams' study of the relation between infant mortality and market milk in the City of Rochester, N. Y. His investigation involved: (1) A critical examination of the infant mortality data of the city for the 11 years from 1900 to 1910. (2) A personal investigation of all of the deaths of children under 5 years of age who were reported to have died of a disease of the gastro-intestinal tract between Aug. 1, 1910, and Aug. 1, 1911. (3) The visiting of 100 to 600 homes in each of 15 sections of the city and the securing in them of (*a*) information as to the number of children under 1 year of age and the kind of food and method of feeding employed; (*b*) the use of market, certified and condensed milks and of ice.

In the study of the mortality statistics, the ailments of which children died were put into four groups, viz.: Group 1, diseases of the digestive tract and of nutrition; to these milk bears a direct causal relation. Group 2, infectious diseases; these are often milk-borne. Group 3, diseases such as meningitis, bronchitis and pneumonia which are not

TABLE 122.—SHOWING IMPORTANT FACTORS IN CAUSING DEATH OF 246 ROCHESTER CHILDREN WHO WERE REPORTED TO HAVE DIED OF DISEASES OF DIGESTION OR NUTRITION FROM AUG 1, 1910, TO AUG 1, 1911 (WILLIAMS)

| Age | Nationality | | | | | Method of feeding | | | | | | | Improper feeding | Food having naught to do with death | Bad care and neglect | Flies as contributing cause | Dirty homes | Parents diseased | Baby diseased at birth | Premature birth | Baby healthy at birth | No records obtainable coroner's cases, etc. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total number | American | Italian | German | Other foreign | Breast-fed | Breast-fed and cow's milk | Breast-fed and proprietary foods | Cow's milk | Proprietary foods | Condensed milk solely | All varieties of food | | | | | | | | | | |
| Under 2 weeks...... | 15 | 8 | 3 | 3 | 1 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 3 | 0 | 1 |
| 2 weeks to 1 month. | 16 | 11 | 2 | 1 | 2 | 4 | 0 | 3 | 1 | 4 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 1 | 7 | 1 | 0 | 2 |
| 1 to 2 months...... | 37 | 18 | 7 | 5 | 7 | 2 | 2 | 4 | 9 | 9 | 3 | 1 | 16 | 2 | 11 | 1 | 12 | 4 | 8 | 6 | 7 | 5 |
| 2 to 4 months...... | 37 | 17 | 10 | 3 | 7 | 4 | 4 | 3 | 2 | 7 | 5 | 2 | 12 | 0 | 11 | 1 | 11 | 3 | 4 | 1 | 6 | 15 |
| 4 to 6 months...... | 37 | 15 | 8 | 1 | 13 | 5 | 3 | 1 | 3 | 8 | 6 | 4 | 20 | 1 | 18 | 2 | 16 | 2 | 6 | 0 | 3 | 8 |
| 6 months to 1 year.. | 65 | 30 | 20 | 6 | 9 | 12 | 4 | 4 | 13 | 9 | 3 | 7 | 28 | 2 | 22 | 3 | 20 | 2 | 5 | 2 | 13 | 11 |
| 1 year to 2 years.... | 30 | 14 | 8 | 3 | 5 | 5 | 3 | 2 | 2 | 1 | 5 | 7 | 9 | 0 | 11 | 2 | 10 | 1 | 3 | 0 | 3 | 7 |
| 2 years to 5 years... | 9 | 5 | 0 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 1 | 6 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Totals............ | 246 | 118 | 58 | 24 | 46 | 35 | 16 | 17 | 31 | 40 | 23 | 27 | 87 | 7 | 75 | 9 | 71 | 14 | 41 | 13 | 32 | 50 |
| | Deaths in which gastro-intestinal disease was contributary cause | | | | | | | | | | | | | | | | | | | | | |
| Under 1 year....... | 48 | 4 | 25 | 3 | 6 | 8 | .. | 4 | 3 | 1 | 5 | 16 | 18 | 1 | 26 | .. | 24 | 3 | 11 | 1 | 13 | 7 |
| 1 to 5 years........ | 8 | 3 | 2 | 2 | 1 | .. | 1 | 1 | 1 | 2 | .. | 1 | .. | 2 | .. | .. | .. | .. | 2 | 1 | .. | 4 |
| Totals............ | 56 | 7 | 27 | 5 | 7 | 8 | 1 | 5 | 4 | 3 | 5 | 17 | 18 | 3 | 26 | .. | 24 | 3 | 13 | 2 | 13 | 11 |

milk-borne. Group 4, deaths due to accident, congenital disease, and other causes bearing no relation to food.

It was found that a large number of children died of diseases of the fourth group and that many more children die of diseases of the third group which are not attributable to milk, than of diseases of the second group which are sometimes milk-borne. The number of deaths that occur in group 2 does not convey a correct idea of its importance, for many children contract non-fatal bovine tuberculosis from milk. The deaths in group 1 are caused by diseases to which milk has a direct relation. So it is commonly used in studying the relation of market milk to infant mortality because diseases of the three other groups are more remotely or not at all related to it. In such studies only the deaths of children under 1 year of age should be used because so many complicating factors enter into the lives of older children that the relation of milk to illness becomes less definite.

As the result of plotting the yearly death rate per 1,000 of population in children under 1 year of age and the average yearly bacterial count of the milk for each year of the period from 1910 to 1911, Dr. Williams showed there was no correspondence between the two. A comparison between the yearly infant mortality rates and these bacterial counts would have been more illuminating.

Because death certificates often do not give data beyond the immediate cause of death and because they are often made out by coroners and physicians that have no intimate knowledge of the case, they are often misleading. So all the deaths of children under 5 years of age which occurred in the period from Aug. 1, 1910, to Aug. 1, 1911, and which the death certificates attributed to diseases of the first groups were studied in detail. The results of these studies appear in Table 122.

It was found that:

"1. Many of the poor families moved within a year, showing that they led a hand-to-mouth existence.

"2. That many of these poor parents went to work, leaving the children with neighbors or to fend for themselves.

"3. That many poor children lacked proper medical attention and that many of them were doctored by the mother or at the nearest drug store. A large number of children die unattended by a physician. The certificates are made out by the coroner and in the table are listed under the heading 'No Records Obtainable.' There is good reason to believe that they properly belong with the cases that died from bad care and neglect.

"4. Seventy-five children died of bad care and neglect and in 87 cases there was a definite history of improper feeding which often meant too frequent feeding of improperly prepared food or of the breast milk.

"5. Of 156 children that died under 1 year of age, 30 were exclusively breast-fed, 27 were breast-fed and received other food besides. 28 received cow's milk

exclusively and 56 were fed proprietary foods which in 17 instances means condensed milk. The large number of deaths among breast-fed children suggests other factors than feeding as the cause of death.

"6. Many children who die of bowel diseases are inherently poorly born; 13 of these children were premature and 41 gave a possible history of congenital disease. Of the latter the parents of 14 have clear visual symptoms of tuberculosis or of gonorrhea.

"7. A study of milk consumption in 5,731 homes with 526 babies led to the conclusion that at least 60 per cent. of the babies are breast-fed, that 15 per cent. are fed on cow's milk and that 10 per cent. are fed on proprietary foods.

"The total milk consumption of the city was 90,000 qt. Of this amount about 3,250 qt. are retailed daily in stores, 1,950 qt. being dispensed in bottles and 1,300 qt. as dipped milk. The latter is very dirty food and a menace to the customers. The store milk is sold where the poor live and where infant mortality is highest. The city consumes about 5,500 cans of condensed milk daily.

"8. While the study shows that about six times as many babies are nursed as are fed on cow's milk and proprietary foods yet more than twice as many babies of the latter class die as of the former.

"9. The more important factors in the group of causes of the infant mortality were:

(*A*) Diseased or physically unfit parents.
(*B*) Dirty, disease-breeding homes.
(*C*) Neglect and bad care.
(*D*) Improper methods of feeding and the use of ill-suited foods.
(*E*) Dirty and disease-carrying milk."

Dr. Price, the health officer of Detroit, Mich., has recently told how the infant mortality in that city was greatly reduced by attention to factors quite independent of the milk supply. The first move was to get the births as completely reported as possible, for the effect of this may be to considerably reduce the infant mortality rate. A city with an infant mortality of 200 per 1,000 births with only half the births reported would have a death rate of 100 per 1,000 births if all of the births were recorded. The next step was to proceed to actually reduce the number of deaths of infants.

The city was divided into 498 districts of six to eight blocks each and the births and deaths of babies in each district was tabulated. Then births were spotted in red and the deaths in black on a map of the district. This work showed that each district might be placed in one of the following groups:

1. No deaths.
2. Deaths 1 to 10 per cent. of the births.
3. Deaths 10 to 20 per cent. of the births.
4. Deaths 20 to 40 per cent. of the births.
5. Deaths more than 40 per cent. of the births.

On July 1, 1914, that is, at the beginning of the most trying season for babies and in what proved to be a hard summer for babies, four of the

board of health nurses were put into the districts where infant mortality was greater than 20 per cent. Each nurse was instructed to reduce infant mortality by reducing infant morbidity and her reliance was to be her own ability to instruct in and demonstrate the hygienic care and feeding of babies. Each nurse was furnished with a map of her district showing by a red dot where there was a baby under a year old and by a black one where the death of a baby had occurred. The maps showed the location of each street, alley, house, barn and privy. The nurses worked from house to house and each nurse had 100 to 150 babies to care for. No milk stations or other baby-saving agencies were in the immediate neighborhood of any of these districts nor were any established. The results attained are illustrated by those in the four districts given in Table 123.

TABLE 123.—REDUCTION OF INFANT MORTALITY IN DETROIT, MICH., IN 1914, BY DISTRICT NURSES (PRICE)

| Period | District | Births | Deaths | Ratio, 3 months | Ratio, 6 months | Ratio, 9 months |
|---|---|---|---|---|---|---|
| Jan.–Mar. | 5–340 | 36 | 9 | 0.250 | ..... | ..... |
| Apr.–June | ...... | 26 | 4 | 0.153 | 0.210 | ..... |
| July–Sept. | ...... | 20 | 3 | 0.150 | ..... | 0.195 |
| Jan.–Mar. | 11–440 | 19 | 3 | 0.157 | ..... | ..... |
| Apr.–June | ...... | 18 | 5 | 0.276 | 0.216 | ..... |
| July–Sept. | ...... | 26 | 2 | 0.077 | ..... | 0.158 |
| Jan.–Mar. | 16–320 | 56 | 10 | 0.178 | ..... | ..... |
| Apr.–June | ...... | 62 | 8 | 0.129 | 0.152 | ..... |
| July–Sept. | ...... | 63 | 6 | 0.095 | ..... | 0.132 |
| Jan.–Mar. | 16–400 | 29 | 6 | 0.206 | ..... | ..... |
| Apr.–June | ...... | 16 | 8 | 0.500 | 0.310 | ..... |
| July–Sept. | ...... | 38 | 2 | 0.050 | ..... | 0.195 |
| Summary of the Four Districts, 5–340, 11–440, 16–320 and 16–400 | | | | | | |
| Jan.–Mar. | | 140 | 28 | 0.200 | ..... | ..... |
| Apr.–June | | 122 | 25 | 0.205 | 0.202 | ..... |
| July–Sept. | | 147 | 13 | 0.088 | ..... | 0.161 |
| | | Rest of city | | | | |
| Jan.–Mar. | | 4,527 | 615 | 0.136 | ..... | ..... |
| Apr.–June | | 4,526 | 468 | 0.103 | 0.119 | ..... |
| July–Sept. | | 4,850 | 649 | 0.134 | ..... | 0.125 |

These excellent results were brought about by correcting errors that are so wrong that many will wonder that the mistakes could have been made of committing them; they include such things as these:

1. Feeding babies beer, coffee, sausage, etc.
2. Allowing the dirty uncovered nursing bottle to stand on the kitchen

table and pouring cold milk into it to feed right to the baby. No attempt at modifying milk.

3. Mother taking no care of her hands; as, for instance, preparing the babies' food without washing them after handling the diapers.

4. Keeping the baby bundled up near the stove or in some other unsuitable place.

5. Bathing the baby improperly.

This reduction of the infant mortality rate was accomplished without in any case changing the milk supply of the neighborhood except that an earnest effort was made to eliminate the use of condensed milk. Detroit has a good milk supply and Dr. Price says distinctly that these results would not have been possible had it been otherwise but the point is that an excessive infant mortality is not wholly attributable to the milk and that the best of milk cannot make up for the errors of bad mothering.

Flies are generally believed to be a factor in infant mortality but it is difficult to determine how large a part they play. It certainly must vary a great deal. They are probably more important in the warm Southern cities than in the cool Northern ones and in a city or ward without sewerage and without garbage collection than in places that have these facilities. They are also more menacing in a dirty house than in a clean one. Several studies have been made to ascertain the importance of fly infection but owing to the many complicating factors involved final conclusions have been drawn in few cases. Recently Platt of the New York Association for Improving the Condition of the Poor has outlined the chief results of an extensive coöperative investigation by the Association of the question of the relation of the fly to infantile diarrhea. The findings, expressed in certain factors devised by the investigators, are that the fly has an importance in causing this rate of 1.9, "dirt" 1.8, artificial feeding 2.4, flies and "dirt" 2.4 and artificial feeding and "dirt" 3.5. By "dirt" is meant the conditions found in homes presided over by easy-going mothers who are satisfied with minimum standards of decency with the result that everything is at loose ends and the house is littered with remnants of meals, dirty clothes, etc.

In discussing this paper Dr. Levy emphasized the importance of proper excrement disposal in Southern cities and the part played by flies in distributing feces. He stated that since 1911, the board of health nurses of Richmond, Va., had been instructed to emphasize to mothers the importance of properly caring for soiled diapers. The effect of laying stress on this point was gratifying. The city had an excellent milk supply for 6 years and general instructions in the care of babies had been given for 2 years; still, the infant death rate from diarrhea per 100,000 inhabitants ranged from 122 to 152 but when the nurses added to their other instruction, information on the care of babies' excrement this death

rate fell to 101 in 1912 and to 84 in 1913 with indications that it would drop to between 70 and 75 in 1914. Flies, of course, are one means of spreading the stools of babies about.

No one who has done tenement house inspection and seen the overfull privies in the back yards and the unscreened windows and has observed milk with a lot of struggling drowning flies in it standing in the hot kitchens and has watched the flies swarming over the nursing bottles has a particle of doubt but that in such habitations food, flies and feces get badly mixed.

Other phases of the problem of infant mortality have been brought out by Schereschewsky in his paper on "Heat and Infant Mortality." In showing the relation of temperature to infant deaths it has been customary to compare the mean temperatures for weekly or monthly periods with the infant deaths in like periods but Liefman and Lindeman in a study of the infant mortality of Berlin, Germany, and also others have shown that to study the direct effect of heat upon infant mortality the daily temperatures and daily deaths must be compared. By using curves constructed on this basis these two authors have demonstrated a well-marked parallelism in the temperature and mortality curves and have noted two well-marked peaks in the mortality curve. These indicate excessive mortality in early summer and in late summer.

The early summer mortality appears with the first atmospheric temperatures above 73.4° and recedes shortly with the advent of cooler weather. In cool years this early summer mortality may be lacking. In this mortality many deaths occur after an illness of 1 to 2 days and the deaths occur from causes mainly referable to affections of the central nervous system.

The late summer mortality extends from the middle or end of July to the first of September, but in cool summers may be absent. It does not recede with the first cool weather but is well-sustained and does not drop markedly till the close of the year. It seems to express the summation of the effects of a long heated period plus irregularities caused by sudden increases in temperature. As summer progresses the number of deaths from gastro-intestinal diseases increases till by the end of August 70 per cent. of the death certificates give diseases of this class as the cause of death. Hot days increase the number of acute cases but these dwindle in late summer. The fact that the late summer mortality curve does not drop with the advent of cooler weather would seem to suggest other causes of illness than high temperature but such is not the fact. It is because the temperatures indoors do not drop with the outside air temperatures that the death curve is maintained.

Observations both in Europe and this country show that the indoor temperature is often higher than outside temperatures. The slow diffusion of heat through the walls is in large measure responsible for this.

Houses with good air circulation cool off more quickly than those that lack it. The number of infant deaths is greatest in houses and districts of the city having poor air circulation. It has been observed that the infant mortality is less for children living in cellars and basements than for breast-fed children living in warmer rooms. The mortality is greatest under the roof where it is hottest.

The observations in regard to the effect of humidity are meager and contrary to what would be expected, for they indicate that infant mortality is highest on hot dry days. In overcrowded tenements the humidity is excessive owing to emanations from the lungs and skin.

Heat produces many effects on the child. It increases metabolism and favors heat retention. The regulation of heat by the body is efficient within narrower limits in babies than adults so that high temperatures are apt to raise the body temperature of children above normal. In hot weather babies and adults both have reduced tolerance for food. This in part accounts for the better results obtained by breast feeding in hot spells than by bottle feeding. The baby takes the first mother's milk and is satisfied, leaving the rich after milk behind whereas in bottle feeding the composition of the milk is fixed and if the baby eats at all, it is likely to overeat. In hot weather the quantity, acidity and activity of the gastric juice is reduced. Certain experiments on laboratory animals lead to the belief that the resistance to bacteria is reduced by heat.

Typical cholera infantum is believed by many to be a direct heat effect and heat is supposed to have a predisposing effect toward subacute diarrheas because it induces reduced tolerance of food, reduced activity of the digestive secretions and reduced normal resistance of the intestines to bacterial invasion. Besides these diarrheas there are the infectious diarrheas due to specific organisms. Flexner, Kendall and Walker and others have proved certain cases of diarrhea of infants to be due to *B. dysenteriæ,* and the last two investigators found certain other cases to be caused by *B. welchii* infections. Other bacteriologists have attributed certain outbreaks of diarrhea to other germs.

In general, infant mortality is class mortality; it is begotten by poverty, ignorance and crime. The poor live in overcrowded insanitary conditions. The expectant poor mother has to work till she is confined and has to leave her offspring soon after, thereby depriving it of nature's food and entrusting its care to some "little mother." The baby suffers from bad food, injudicious feeding and other forms of ignorance. Criminal parents are apt to be alcoholics, the sufferers from venereal disease and often to be mentally weak. Illegitimacy means that the newborn is likely to receive gonorrhea and syphilis from its parents and to be neglected by them. In England and Wales in 1909 the death rate of illegitimate children was 211.1 and of legitimate children 104.

The subject of infant mortality has been merely crudely outlined in the preceding paragraphs but it cannot be pursued further. Enough has been said to show that dirty and infected milk is responsible for part of it, but it cannot be successfully maintained that it is for all of it. Any health officer who expects to reduce the infant mortality rate to where it ought to be by the sole agency of a clean milk crusade deludes himself.

One method of coping with the problem of infant mortality adopted by boards of health is to try to reach the mother in the home. Circulars are issued to expectant mothers telling them to get medical advice, giving them simple rules in regard to dressing, exercise, eating and bathing and warning them not to use patent medicines. Some boards employ nurses and in summer have them devote much of their time to teaching the poor how to care for babies. There is less effort to reach the well-to-do but they are sent circulars on the care of milk in the home which emphasize the necessity of being particularly careful in the selection and care of milk for babies and tell how to pasteurize it. Some of these circulars touch on the use of bottles of the thermos type for holding milk and other liquids that are subject to bacterial decomposition.

**Bottles of the Thermos Type.**—Such bottles have been studied from this standpoint by Rogers, by Tonney and by Davis. Rogers showed that these bottles act as very effective incubators when their contents reach the temperature of bacterial multiplication that is between 50° and 98°F. Milk put in them at a temperature of 102°F. and containing 23,900 bacteria per cubic centimeter in 4½ hr. had a temperature of 95°F. and had 1,420,000 bacteria per cubic centimeter and in 7½ hr. its temperature dropped to 93°F. and its bacterial count had increased to 27,000,000 bacteria per cubic centimeter. If inadequately cooled milk, that is milk at about the temperature it would have in the ordinary ice chest, was put in them it soon reached a temperature where rapid bacterial multiplication took place; thus milk put in the bottles at 46.4°F. and containing 49,000 bacteria per cubic centimeter in 24 hr. had a temperature of 64°F. and a bacterial count of 2,140,000 per cubic centimeter. Thoroughly cooled milk kept well. If put in the bottle at 23°F. with a bacterial count of 29,000 per cubic centimeter in 24 hr. the temperature was but 37.4°F. and the count 36,000 bacteria per cubic centimeter and in 48 hr. the temperature was 57.2°F. and the count only 124,000 per cubic centimeter. Tonney showed that milk might be put in these bottles at a temperature of 150°F. and kept for 6 to 8 hr. without bacterial multiplication ensuing but that as soon as the temperature of the milk drops to about 115°F. rapid bacterial multiplication took place. Davis showed that the bottles cannot be sterilized by washing them with boiling hot water and that in 12 hr., milk that had been heated to various temperatures between 120°F. and 212°F. had bacterial counts so high that

its use was unsafe. From these investigations it appears that the use of these bottles for holding milk and other liquids subject to bacterial decomposition is commendable when the temperature is kept below 50°F. but that they become highly dangerous if the temperature is allowed to rise above this point. They should never be used to hold hot perishable foods.

**Child Welfare Stations.**—Besides these rather general methods of combating infant mortality the child welfare stations or infant milk depots are used in more definite campaigns against the evil. In France they may be traced back to the "L'Oevre de la Maternite" founded in 1890 by Hergott at Nancy. The mothers of children born in the institution under his charge were required to bring their babies back for examination 1 month after birth and were given a present of money if satisfactory progress had been made. This charity was the precursor of the "Consultation de Nourrisson" founded by Boudin at the Charité Hospital at Paris in 1892, at the Maternité Hospital in 1895 and at the Clinique d'Accouchement Tarnier in 1898. There are two types of consultation de nourrisson, namely: (1) those attached to maternity hospitals where the mothers are accouched in the hospital free of charge and their babies kept under medical supervision for 2 years succeeding birth; and (2) those not attached to maternity hospitals. The two sorts of institutions are conducted in the same way. Every effort is made to encourage breast feeding but where it is impossible for the mother to nurse her baby, sterilized milk is supplied. Weekly, the mother must bring the baby to the hospital where one of the medical staff examines, weighs it and records its weight and other particulars.

An offshoot from the Consultation de Nourrisson is the "goutte de lait" which is in reality a milk dispensary from which babies are fed upon sterilized milk without modification. Breast feeding is encouraged but usually the great majority of infants are bottle-fed. The first goutte de lait was established by Variot at Paris in 1892 in connection with the Belleville dispensary. The name goutte de lait was first used by Leon Dufour who gave it to the institution he established at Fecamp in 1894 which was the first separate institution of this sort and the first provincial goutte de lait. These institutions sprang up all over France and in all countries of the world where cow's milk is used. The first goutte de lait in the United States was established by Hoplik at the Eastern Dispensary now called the Good Samaritan in New York City in 1889. This was followed by the milk stations of Nathan Straus in the same city in 1893. Philanthrophists and charitable organizations of various sorts established them first in the large cities and then in the smaller ones till now there is nothing unusual about a milk station. Goler, the health officer in Rochester, N. Y., started the first station to be operated by a board of health. The innovation attracted much attention and resulted in it

being recognized that the maintenance of these depots may properly be one of the municipal health department's functions.

With regard to the milk stations in the United States a brief statement should be made. Their object is to reduce sickness and death among babies which they do by charitable practices, furnishing medical advice and by educative effort among the mothers. Since they aim to reach babies most of their milk is furnished to infants under 1 year of age and practically all of it to children under 3, but some milk is supplied to expectant mothers and to invalids. Almost all of the stations are under medical supervision and in the large ones well-supplied with money, the regular staff consists of a physician, a registered nurse and a matron. As each baby is brought to the station it is given an examination by the physician, it is weighed and its record on the books of the station is started. If the child is in need of medication, it is given. The mother is encouraged to feed the child from the breast but if there is a deficiency of breast milk, enough milk is sold her to eke out the needs of the child or if breast feeding is impossible she is allowed to purchase all the child needs. The milk is usually pasteurized but some stations furnish certified milk and many modified milk. The milk is usually put up in bottles each of which holds a single feeding. Some stations sell milk both in these small bottles and in ordinary bottles. The mothers are instructed in the care of the child, of themselves and in proper feeding of the babies. They are also taught how to modify milk. Generally the great majority of the patrons of the stations use milk and so an ample supply of good clean milk is essential to the success of the station. Milk is sold at cost but even so it often happens that it is higher-priced than dipped milk that is sold in the neighborhood, consequently it has to be made plain to the mothers that it is worth more. Some cannot pay the difference in price and others are too poor to pay at all. Such people must be helped and this is done either from the funds of the station or through the agency of established charities. Ice is necessary to keep milk in the homes but often there is none so that the station has to see that ice is provided and it often happens that a considerable ice charity develops. Usually regular attendance is made a condition of obtaining milk.

The location of the stations is important; they ought to be placed where there are many babies in need of help. In this matter the advice of the health department is to be sought. The sphere that a station can occupy is limited. About 300 babies is the maximum number it can serve well and a nurse should not be expected to look out for more than 100 babies or at most 150. The building occupied should be convenient of access but its rent need not be high. If possible there should be three rooms, a large one for dispensing the milk and for lectures, a room for preparing the milk and a consultation room for the doctor and nurses.

In opening a new station the patronage must be built up. Conspicu-

ous notices of the station placed in the shops, drug stores and saloons of the neighborhood help. Newspaper publicity is of great value but the house to house canvassing of the nurses is most important. One criticism that is made of milk stations is that they fail to reach those who need help most. The overburdened discouraged tenement house mother does not find the time and energy to go out for the relief that is at hand; it must be brought to her. The nurse must not only interest the mother in the station and make her its patron but must win her confidence enough to be allowed to straighten out the home and to advise in the feeding of other children. If extreme poverty exists, its cause must be found and the effort made to alleviate it. Once the mother is made a patron of the station she can usually be made to feel that she is doing well to spread its virtues among her neighbors and bring them to it, too. The 6th Annual Report of the Boston Milk and Baby Hygiene Association states that 40 per cent. of the babies came to the stations from mothers and friends, 18.5 per cent. from board of health nurses, 10 per cent. from district nurses, 13 per cent. from milk station nurses, 13.5 per cent. from doctors and hospitals, 2.5 per cent. from settlements, 1 per cent. from relief agencies and 1.5 per cent. from miscellaneous sources. Of course, elsewhere it would very likely be different but this statement is interesting as showing the influence of mothers and nurses in upbuilding station work.

The proportion of sick and well babies treated at different milk stations varies a great deal and so does the infant mortality at the different stations. The efficiency of station management, the character of the population served, whether or not it stands in great need of the help the station offers, and the activity of the nurses in ferreting out ailing children, all are factors in determining the record of the station in these matters.

The educational work carried on by the stations is of the utmost importance. The distribution of leaflets in various languages telling about the station, how to care for the baby and how to feed it are helpful but the great work of this sort is the lecture and demonstration work at the station. In carrying on this, effort should be made to reach the "little mothers" both because it teaches them how to care for their charges and because it prepares them for motherhood. Some stations distribute small prizes to the children for essays on topics developed in the lectures. The compositions are often naively touching and show the vital interest taken.

Milk stations by extending their work frequently become true child welfare stations. They can do prenatal work among the mothers, exercise control over the midwives by making them feel that their work is under observation, follow up foster mothers in charge of boarded babies and teach mothers how to feed and bring up children under school age. This last work is very important for ordinarily these children escape all

care except such as their busy mothers and the streets give them. They have precious little medical attention and often suffer for the need of such advice as the school physician might give.

To be successful a station must have good financial management. Station expenses fall under the heads of (1) supervision, (2) maintainance, (3) medical and (4) loss on sales, including relief granted. A competent treasurer should handle the receipts and disbursements and should render an audited account every year.

In the large cities other organizations carry on relief work for sick babies that helps to reduce the infant death rate. For instance, in Boston in summer the floating hospital carries on a valuable work in taking these babies down the harbor out of the heat of the city and in giving them medical treatment. Its scientific staff make bacteriological investigations, studies on milk, on feeding, etc.

**Milk Supplies of Large and Small Cities Contrasted.**—Since the milk supplied small cities is produced in the surrounding country and is distributed when only a few hours old and since the farmers would naturally be presumed to take a keen interest in the business, inasmuch as they deliver their own milk to customers with whom they are acquainted, those who are unfamiliar with such supplies might think them to be better than those of the big cities but often such is not the case. Usually there is only a small amount of capital invested in the milk business of small cities, consequently the animals are poorly housed and the dairies meagerly equipped. Theoretically, the dairy business in the small places is protected by laws but practically it is not for there are neither funds nor officials to enforce them. There are no inspectors and no laboratory facilities, therefore there is no one to instruct the dairymen in the modern methods of milk production nor to uphold the legal requirements for market milk. The citizens commonly give little thought to the milk supply, know very little about milk and, failing to appreciate the importance of a good milk supply, are unresponsive to efforts to improve it. The small tradesman, being apprehensive that public discussion of the milk question and inspection of dairies will offend the farmers and result in the withdrawal of their trade, discourage movements to better the milk supply. The consequence of all this is that there is virtually no standard of milk quality, that slovenly competition creeps in, that milk is sold cheap, and that more or less adulteration of the milk is practised. In not a few towns the milk business does not pay and there is dearth of milk. Sometimes these small places suffer from milk-borne infections without knowing it. Bolduan traced the undue prevalence of typhoid fever for the past 25 or 30 years in Camden, N. J., to one of the local milk dealers who was a carrier. Hill found that all typhoid fever in North Branch, Minn., for 5 years was derived from the wife of a dairyman who washed the cans. In Belleville, Ill., typhoid fever was

disseminated in the milk of a dairyman whose wife was a carrier for 7 months before the cases became sufficiently numerous to direct suspicion to the milk route. Lack of official supervision makes the occurrence of such cases more likely.

Conn, in a preliminary report on the milk supplies of small cities in Connecticut having 1 to 20 dealers, found that preservatives were rarely used, that the butterfat was often below legal standard but this he attributed to careless mixing of the milk rather than to skimming, and watering was uncommon. Bacterial counts ran from 100 per cubic centimeter to 12,000,000 per cubic centimeter; 42 per cent. were above 50,000 and 23 per cent. were above 1,000,000 per cubic centimeter. In summer few counts were under 500,000 per cubic centimeter which he believed was due to insufficient icing. He continued the work and through the coöperation of the State Board of Health, county health officers and local health officers was able to arouse interest in the small cities. The samples examined increased to 300 per month and covered practically all of the towns and cities large enough to have milk routes. He believed that he demonstrated the feasibility and usefulness of a central laboratory in coöperating with small places in controlling these milk supplies. As a result of his work, in 2 years 25 milk inspectors were appointed. Previously there had been but two in the State. In towns where inspectors were appointed the supplies improved, but in others little progress was made.

As an illustration from the South of conditions that may obtain in a small city the experience of Jackson, Miss., where the situation was taken in hand by the State Board of Health, may be cited. One hundred and forty milk analyses were made. Before inspection, the scores on the "official" score card varied between 11 and 69 and the few bacterial counts ranged from 50,000 to 200,000,000 and averaged 22,000,000 per cubic centimeter; 3 months later in August, 1911, the counts ranged from 88,000 to 5,800,000 and averaged 1,200,000 per cubic centimeter. The following was the range of butterfat in the milk of the different dairies before and after inspection was begun:

| Dairy No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Average |
|---|---|---|---|---|---|---|---|---|
| Before | 2.8 | 4.1 | 2.9 | 2.8 | 3.6 | 2.6 | 0.8 | 2.8 |
| After | 5.0 | 6.4 | 6.1 | 5.0 | 6.3 | 6.0 | | 5.8 |

Apparently but two dairies were selling unskimmed milk prior to the appointment of a permanent city dairy inspector, but under the guidance of one, the dairymen willingly improved their premises and after a little instruction adopted approved dairy methods.

Hastings in 1910 made the statement that the efforts of boards of health to improve milk supplies and the concentration of the milk busi-

ness in the hands of large dealers who are better able than small ones to carry out the regulations and introduce improvements, was producing good milk in many cities but that in many of the smaller cities of Wisconsin it was almost impossible to get good milk.

Trueman in 1905 and 1906 investigated the milk supply of Chicago and of 26 cities of Illinois that had populations of from 10,000 to 60,000. He reached the conclusion that the chances of getting good milk were better in Chicago than in the other cities, which he attributed to the lack of inspection in the smaller places. In a long table of butterfat tests of milk collected in the 26 cities, are 191 analyses of milk that was not doctored with formaldehyde. The average butterfat test of these 191 samples was 3.53 per cent. and the average total solids was 11.57 per cent. Of the samples 37, or 19.3 per cent., were below the legal standard of 3 per cent. for butterfat and 120, or 62.8 per cent., were below the legal standard of 12 per cent. for total solids. Had not the standard for butterfat been so very low the butterfat test would have shown more illegal samples. Out of 210 samples tested for butterfat, total solids and formaldehyde 19, or 9 per cent., showed the preservative. In 156 of the samples in which butterfat and total solids were determined the amount of sediment was estimated. One hundred and thirty-five, or 86.5 per cent., carried visible dirt; in 33, or 21 per cent., the amount was large enough to be objectionable to consumers who are used to dirty milk and in 45 per cent. to those who would object to plainly visible dirt on the bottom of the bottle.

Trueman brings out the fact that in the small towns many of the health commissioners absolutely refused to move in the matter of milk inspection because they did not wish to incur the enmity of the milk dealers. The ignorance of a certain class of health officers, in this case the man was a physician, is illustrated by the letter of one who wrote to know what preservatives, if any, could be used without being harmful in the milk and without violating the law.

In 1913 the author investigated the milk supply of the twin cities of Urbana and Champaign, Ill. These two cities formed practically one community of 22,500 inhabitants. Urbana paid its health officer $100 a year and Champaign $180 which means that the offices were perfunctorily administered. The cities had identical milk codes of the modern sort but no attempt was made to enforce them. Table 124 shows that in 1911, 20 of the dairies that supplied the cities had an average score of 11.9 for equipment and 13.1 for methods with a total average score of 25.5 on the "official" score card. These scores fairly represented the state of the average dairy farm supplying the cities.

The late G. M. Whitaker held that milk from dairies scoring less than 40 should not be a marketable commodity. There was no evidence that skimming and watering were practised and preservatives were not used,

TABLE 124.—AVERAGE SCORES OF 20 DAIRIES[1] IN URBANA AND CHAMPAIGN, ILL., 1909, 1910 AND 1911

| Scorer | Date | Equipment | Methods | Total score |
|---|---|---|---|---|
| C. H. Yates | 1909 | 12.58 | 15.79 | 28.37 |
| C. H. Yates | 1910 | 13.50 | 18.08 | 31.58 |
| H. E. McNatt | 1911 | 11.90 | 13.10 | 25.50 |

[1] It does not appear that the same dairies were scored at the different scorings but in all probability many of them were the same.

but the milk was dirty and had a high bacterial count. The tests of the milk of 19 dairies supplying dealer A and of that of 21 dairies supplying dealer B made on 2 different days in the middle of October may be taken as illustrations of the quality of milk sold. The milks of the dairies supplying dealer A had an average fat test of 4.3 per cent. with tests ranging from 3.2 to 5 per cent. of butterfat, while the acidity, expressed as percentage of lactic acid, averaged 0.188 per cent. and varied from 0.166 to 0.216 per cent. The milks of the dairies supplying dealer B had an average fat test of 3.8 per cent. with tests ranging from 2.7 to 6.2 per cent. while the acidity averaged 0.199 per cent. and varied from 0.159 to 0.234 per cent. The milk of four, or 21 per cent., of the dairies supplying dealer A had a bacterial count of less than 200,000 per cubic centimeter and would fall in grade A; that of 13, or 68 per cent., of his dairies had a count of between 200,000 and 1,000,000 and would fall in grade B and that of 2, or 11 per cent., would fall in grade C. Of dealer B's dairies two, or 9 per cent., would be classed as grade A, six, or 29 per cent., as grade B and 13, or 62 per cent., as grade C. It thus appears that according to the New York grading not over 10 per cent. of this milk was fit for consumption raw while over 10 per cent. of dealer A's milk and over 60 per cent. of dealer B's milk was fit only for industrial use. The high counts are partially explainable by the dirty condition of the milk but the fact that the morning milk was not cooled and was hauled in that condition for an hour or two over hot roads to the dealer's bottling plants was largely responsible for the high counts and acidity.

It is not intended to convey the impression that the milk of all small towns is bad and to deter people from using it. Undoubtedly some small cities have good milk supplies but many do not and the difficulties in the way of helping them to better ones are very great. At first thought it might seem that the State boards of health might be of assistance but it is doubtful if they can be. Very few have nearly enough men to carry on their milk work properly. The consequence is that their usual mode of operation is to have their inspectors drop down on a town where they hastily score the dairies and collect milk samples from the delivery wagons. Those dealers whose milk is below grade are prosecuted. This sort of

thing is not going to help very much. What is needed is the patient sympathic education of consumers and dealers, and for this work there seem to be neither funds nor officials.

In contrast to the small communities the large cities are served by milk companies with ample capital and with highly trained men. The city boards of health have well-equipped laboratories and inspectors enough to cover the dairies fairly well. The consequence is that where politics does not blight the efforts of those who want good milk supplies, something akin to them is obtained. The chief inspector's staff commonly consists of dairy inspectors who devote their time to producing dairies, milk plant inspectors, who look after the various types of plants where milk is prepared for the market and city inspectors who attend to the shops and restaurants where milk is sold, to the delivery wagons, to the collection of milk samples, and to complaints made by consumers. In some cities where the bureau of food control is organized independently of the milk inspection bureau the former undertakes the inspection of stores where milk is sold. The cost of milk inspection varies a great deal according to various factors, among which may be mentioned the distance of producing dairies from the city and from each other, the location of milk plants and their number, the amount of laboratory work and the salaries paid. The expenditures for milk inspection are never lavish. Generally the legislative branch of the government which votes the funds provides inadequately for the work so that those in charge have to economize severely. In some places no attempt is made to inspect dairies that are far from the city and in many others an inspection once or twice a year is all that can be made.

**Cream.**—The quantity of cream used by the American people is steadily increasing; in fact, in some markets it is the price of cream that sets that of milk. Rich creams, those of 35 per cent. and more, keep well so that they are more easily shipped long distances than is whole milk. This often results in the cream supply of a city being derived from sources entirely distinct from the milk supply; a dairyman may produce all of the milk he sells but purchase all of the cream he markets from a creamery 300 miles away. Cream ought to be produced and handled in the same careful way that milk is and in particular the separators should be kept scrupulously clean but sanitary supervision of the cream supply is frequently neglected. Apparently there is no other reason for this than that cream is used less generally than milk and so there is somewhat less likelihood of people becoming infected from it than from milk. Nevertheless, the danger exists for epidemics like that, for instance, of septic sore throat in Concord, N. H., have been traced to cream. Moreover, the fact that in extremely hot spells and at other times, also, a temporary heavy demand forces dealers to get cream from unusual sources, makes it very necessary that the quality of the cream supply

be protected. Boards of health should not only look after conditions that attend the production and shipment of cream but they should make sure that it is properly handled at soda fountains, restaurants, hotels, candy factories, ice cream factories and other places where it is used. Care should be exercised also to see that cream is properly branded as to its fat content and that it is not adulterated by the substitution of other fats for butterfat. Good cream and the products made from it are healthful and their increased use by the public is wholly commendable; every effort should be made to insure their continued purity and safety.

**Daily Consumption of Milk in the Larger Cities of the U. S.**—The magnitude of the task of controlling the milk supplies of our large cities may be appreciated from the consideration of a few facts relative to the production and distribution of milk in some of them.

In Boston the milk comes from all of the New England States except Rhode Island, from New York and from Canada. It is produced on about 6,700 farms the furthest distant of which is 270 miles away. In 1914, the daily consumption of milk was 308,880 qt. which were distributed by 205 wagon dealers and in 4,099 shops. In 1911, 215 wagon dealers used 666 wagons in delivering the milk. Of these 134 firms used one wagon, 48, two wagons, 11, three wagons and 6, four wagons. One dealer used 25, one 50 and one 100 wagons. In 1914 there were consumed in the city 1,163,620 gal. of 40 per cent. cream of which 373,030 gal. were sold to householders and 790,590 gal. were sold for manufacture. There were also used 1,874,275 gal. of 15 per cent. cream of which 4,159,270 gal. went to manufacturers. Five thousand, one hundred and thirty-six dairy inspections and 2,246 milk plant inspections were made; 21,984 samples were examined.

New York City in 1912 drew its daily milk supply of 2,500,000 qt. from 44,000 farms located in New York, New Jersey, Pennsylvania, Connecticut, Vermont, and Massachusetts. Cream was received also from Ohio and Canada. The "milk shed" covered an area of about 50,000 sq. miles. The milk was produced by 350,000 cows and was shipped from 1,100 creameries over 11 different railroads, the shortest haul being 50 miles and the longest 425. It was received in New York at 15 different terminals, delivered in 5,500 wagons and dispensed at 14,000 stores. It was estimated that 127,000 persons handled the milk daily. There were 56 milk inspectors of whom one-half were assigned to country duty and one-half to city.

In Chicago in 1910 the milk was derived from 17 counties of the States of Wisconsin, Indiana and Illinois. The daily supply amounted to 1,000,000 qt. and was produced by 120,000 cows on 12,000 dairy farms. At that time 75 per cent. of the milk was pasteurized and two-thirds of that sold at retail was bottled in the country.

The daily consumption of milk in Detroit in 1914 was 260,000 qt., of

which 7 per cent. was produced within 10 miles of the city, 38.8 per cent. within 10 to 20 miles, and 28.8 per cent. within 20 to 30 miles. One per cent. of the milk was sold at the stores. At the present time all milk except certified and class A milk is pasteurized in 66 milk plants of which 56 use the vat system and 10 the continuous. Philadelphia consumes 540,000 qt. of milk daily, Baltimore 137,000, St. Louis 125,000 and New Orleans 80,000.

**Annual Reports.**—The annual reports of the milk inspection bureaus broadly speaking are of two types. One is little more than a statement to the tax-payers of the cost of conducting the work. The number of employees and the total amounts of their salaries are given, and also the number of inspections, chemical and bacteriological analyses, a summary of their results, etc., appears in tabular form. Frequently such reports form part of a town report or of some municipal officer and are tucked away inconspicuously therein. They are of little value to the ordinary man. The other type appeals to milk consumers in general and aims to advance the interests of producers, retailers and the public. Such reports are published separately; they should always contain a plain statement of the location of the milk-producing area and of how the milk is brought to the city. Where there are several milk-producing districts the source of each dealer's supply should be indicated. It would seem almost unnecessary to mention this but one may peruse report after report and not find a hint as to where the milk comes from. It should be told how much milk of different classes is used, as, for instance, of the certified, the inspected and the ordinary milk. The requirements for pasteurized milk, the mode of enforcing them and the amount of such milk used should be stated. If the milk is graded, the grades should be defined and the quantities of each used should be made known. In the smaller cities a brief description of each dealer's supply can be given. An endeavor should be made to present analytical results in such form that they will be intelligible to people who use the milk. The writer firmly believes that the dealers should be rated on the basis of the quality of the milk sold during the year and that in making up this rating the dairy scores, the butterfat, content of the milk and the bacterial counts, should all be taken into account. The reports may well treat of some feature of milk supply such as the necessity of keeping milk cool, the abuse of milk bottles, the value of milk as a food or the like. Any particular defect of the supply may be discussed with the public or some commendable feature may be dwelt on. Often an account of what inspectors are doing tends to lead the public to appreciate their services.

**The Public Milk Supply.**—In conclusion, it may be said that an impure raw milk supply is a source of disease and death to the community that uses it. Its victims are chiefly the women and children because they partake of milk most freely. Such milk is not the cause

of all cases of disease that may be milk-borne for these diseases are transmitted in other ways, but communities that neglect to protect their milk supplies are likely to and probably nearly always do suffer an excess of these sicknesses. The milk business itself does not thrive, for the milk is regarded with suspicion and is not of the character to appeal to the housewife.

The milk supply of the future will probably be graded because failure to do so makes mediocrity the standard; those who are able and willing to produce superior milk cannot afford to compete with those who will not. The establishment of grades gives every dairyman the opportunity to produce the kind of milk he wants and to sell it at the price it merits. A regulated supply furnishes the conditions under which the dairy business prospers most, for it eliminates unfair competition and establishes public confidence in the product. An abundant supply of inspected, pasteurized milk is one of the greatest blessings a community can have for it affords cheap wholesome food of such excellence that it finds its way into every home.

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